2000 ENVIRONMENTAL AUDIT OF PRINCETON UNIVERSITY

2000 ENVIRONMENTAL AUDIT OF PRINCETON UNIVERSITY

Conducted by

Undergraduate Students in the Environmental Studies Program

Compiled and Prepared by

Elizabeth Bernier ’02 and Brooke Kelsey Jack ’03

PRINCETON ENVIRONMENTAL INSTITUTE

(PEI)

PRINCETON UNIVERSITY
PRINCETON, NEW JERSEY
2001

CONTENTS

INTRODUCTION vii

EXECUTIVE SUMMARY ix

SUMMARY OF RECOMMENDATIONS xiii

Chapter 1 Procurement 1

Chapter 2 Energy Use 9

Chapter 3 New Buildings and Renovations 16

Chapter 4 Water Use 21

Chapter 5 Groundskeeping 27

Chapter 6 Transportation 34

Chapter 7 Food Services 42

Chapter 8 Solid Waste and Recycling 47

Chapter 9 Toxic and Radioactive Waste 54

Chapter 10 Academic Opportunities 59

Conclusion 64

ACKNOWLEDGMENTS 67

INTRODUCTION

In 1994, the Princeton Environmental Reform Committee (PERC) was created, inspired by the Campus Earth Summit held at Yale that same year. PERC was composed of students, faculty, and staff working to together to develop and improve campus ecology. Their stated mission was to institutionalize environmental improvements at Princeton that would remain effective for many years to come. Because the coalition was a joint venture between students and administration, the hope was that changes promulgated by the coalition would be long lasting and effective, unlike strictly student-initiated changes.

In order to focus its efforts on the areas most in need of improvement and of greatest impact, PERC conducted an objective environmental audit of the campus that began in the spring of 1994 and continued into the summer. The audit was sponsored by the Facilities Department, which hired two PERC members to work on it full time during the summer. The audit was completed in the spring of 1995. Over the year during which the audit was conducted, thirty members of PERC evaluated campus practices and decision making, reviewed regulatory policies, interviewed University officials, and researched other universities' policies. Though not a comprehensive audit, it was designed to serve as a paradigm for future audits.

The audit highlighted areas in which easily implemented changes would result in significant improvements throughout the University, such as reducing its environmental impact, promoting administrative efficiency, and returning an economic benefit. Detailed recommendations for implementing changes were made whenever the potential for improvement was clear. Members of PERC hoped that the University would take action on the recommendations so that it could lead by example in moving our society toward an environmentally sustainable future.

In Fall 1999, momentum to update the PERC audit was provided when Professor Michael Celia assigned his students in the Environmental Studies core course, ENV 201, research projects that would update many of the chapters from the PERC audit. Students investigated the policy and practice changes that have occurred since 1995 and interviewed University officials to determine the causes of any developments. These reports served as the foundation for this update of the audit (see the list of student participants under "References" at the end of each chapter).

The Princeton Environmental Institute (PEI) decided to sponsor a complete update of the 1995 PERC Environmental Audit and impetus for this effort was provided in part by the New Jersey Higher Education Partnership for Sustainability (NJHEPS). Founded in 1999, NJHEPS is a coalition of New Jersey colleges and universities striving to promote environmental sustainability, made possible by a grant from the Geraldine R. Dodge Foundation. The primary goals of the coali-

tion are to promote environmental sustainability by fostering cooperation between universities and colleges and linking them to a broader network of environmental sustainability advocates. The regular completion of environmental audits is a tool of the coalition in measuring the success of environmental impact reductions. This audit was funded by a grant from the NJHEPS to PEI, as well as PEI funding.

The main objectives of this audit were twofold: to investigate changes in University policy and their environmental impact, and to determine the most likely causes of these changes. We evaluated the status of the major recommendations that were made in the PERC audit, attempting to determine if any of them had been addressed. Whenever possible, we compared data from the time of the PERC audit and from the current academic year and note the differences. We conducted interviews and meetings with University officials throughout the spring 2000 semester to gather information and data about these changes.

Whenever the recommendations made in the original PERC audit were not addressed, we evaluated the current situation to determine where these recommendations might still be useful. In other instances, we have also made recommendations to address issues that were not raised in the audit. Finally, in the many cases where recommendations from the PERC audit were addressed, we identified areas that were still in need of further improvement. The format of the PERC audit was restructured slightly, and we added a new section on Groundskeeping.

We hope that the University will use the documentation and our evaluation of progress over the past five years when planning its approach to improving its environmental sustainability. Continuing to make changes and initiating additional ones will require a strong commitment from students, faculty, and staff. By taking the actions recommended in this audit, the University will achieve a significant reduction in its environmental impact. Though these reductions may not have a huge impact on the larger society, Princeton will, through its own example, establish itself as an environmentally progressive educational institution and demonstrate the commitment needed from all of society in order to move toward global environmental sustainability.

Liz Bernier and Kelsey Jack

EXECUTIVE SUMMARY

CHAPTER 1 – PROCUREMENT

The University has continued to use "green-buying strategies" such as buying items in bulk, buying fully recycled items or those with some recycled content, and reducing or eliminating the use of toxic materials. Recycled paper use has increased in some offices but decreased in others, yet seemingly contradictory explanations have been offered for these opposite trends. However, these changes have occurred mostly on a small scale, resulting in relatively little overall reduction in the University's environmental impact. The main recommendations of the 1995 audit were not addressed, so they still comprise our main recommendations in the current one. Two primary improvements that should be made are (1) the implementation of a 5% recycled product purchasing standard, and (2) a uniform set of environmental criteria to be used in negotiating all purchasing contracts. Increased communication between the major paper users on campus (Computing Information Technology, Library Photoservices, and the Office of Printing and Mailing) could facilitate increased use of recycled paper and use of paper with higher recycled content.

CHAPTER 2 – ENERGY USE

Energy use at the University has undergone a dramatic transformation since the Princeton Environmental Reform Committee's 1995 audit due to the construction of a cogeneration plant to meet electricity and heating needs. Built primarily for economic reasons, this new facility has greatly reduced the University's environmental impact. Over the past five years, buildings have continued to be added to the Central Supervisory Control System (CSCS), a central computer that monitors heating and cooling in connected buildings. The University's demand for energy will continue to grow as the campus and student body expand. Installing efficient lighting fixtures and attaching all buildings to the CSCS will keep energy needs low. Heating of the dorm rooms should be individually controlled to eliminate wasted heat energy. Reassessing a payback period to allow more time for energy-saving projects or creating a special fund for "green" energy innovation should be priorities.

CHAPTER 3 – BUILDING DESIGN AND RENOVATIONS

Several specific efforts have been taken since 1995 to use green architectural principles and to recycle materials with the goal of lowering the operating costs of all buildings. The University continues its practice of recycling old buildings whenever possible to conserve resources. The 1995 Princeton Environmental Reform Committee (PERC) audit had suggested that the University utilize the new wave of construction, including the new campus center, to adopt a stringent, ecologically conscious construction policy. However, the University has yet to address this recommendation, partly because

each project has unique demands. Nonetheless, the University should develop an environmentally conscious construction and building policy to minimize the environmental damage caused by new buildings and by renovations.

The entire construction waste disposal process, with one notable exception, is left to individual contractors and is expected to be carried out in the cheapest way possible. We reiterate the 1995 audit recommendations that alternative construction materials be used when possible and that a set of environmental criteria (outlined in Chapter 1) be applied to construction material purchases. Due to its large environmental impact and the potential to apply environmentally sound practices, the construction waste disposal process should be monitored by the University with the goal of reducing its environmental impact and the University's procurement and disposal costs.

CHAPTER 4 – WATER USE

Records of water use on campus are taken from monthly water meter readings and are kept by the Business Office in a random manner, making them rather inaccessible for analysis. Water use on campus has increased in almost all sectors since the time of the 1995 audit. The largest increase in demand is due to the installation of air conditioning in new and renovated buildings. General campus expansion has also significantly increased the University's water needs. As new construction and renovations occur, old plumbing fixtures are replaced by more efficient ones. Economic concerns have helped inspire the push to conserve water through the installation of such devices, as well as making improvements in cooling efficiency by connecting buildings to the Central Supervisory Control System. Preemptive measures to reduce cooling and water needs will result in more efficient new and renovated facilities. Monitoring water consumption by sector through the Business Office will allow assessment of changes in water use due to policy improvements. Raising student and employee awareness of water use may be the most cost-effective method for reducing demand.

CHAPTER 5 – GROUNDSKEEPING

Over the past few years, several changes have been made to enhance groundskeeping efficiency and further reduce its environmental impact. Among these changes are improvements to the Integrated Pest Management System and the hiring of a landscape architect to coordinate campus landscape design. Grounds and Maintenance recycles 100% of the organic waste, masonry, and metal waste generated on campus, but not other construction waste such as wood and glass. We recommend that the reuse of construction waste from small projects be explored and that shade trees continue to be used to reduce energy use in buildings. Landscaping plans should continue to emphasize native species, and vegetation should be minimally pampered to allow it to develop more naturally. More reunion sites should continue to be added so that they can be alternated. Vehicular access to grassy quads should be restricted during check-in and check-out as well as throughout the year.

The pesticides section of the 1995 PERC audit is the only portion of the audit that corresponds to this chapter. Recommendations in that section included reducing use and investigating alternative herbicides to the reportedly carcinogenic ones used at that time. Reductions have been made, but the most popular pesticide, "Roundup," is still in use. We recommend continuation of the efforts to reduce pesticide use and investigate less harmful alternatives such as manual weeding.

CHAPTER 6 – TRANSPORTATION

At the time of the 1995 audit, an Employee Trip Reduction Plan (ETRP) held enormous promise for improving employee commuter practices. However, a change in state law has since made this plan voluntary, and the ETRP has been dropped. The number of cars on campus, represented by parking spaces, has almost doubled, going from 4,180 in 1995 to 8,115 in 1999. Fuel consumption by the University has gone up by 2,880 gallons during that time, due to a small expansion of the vehicle fleet coupled with an increase in use. Centralizing the management of the vehicle fleet, which is currently managed by individual administrative and academic departments, would improve its efficiency. Implementing parking fees for employees and increasing the cost for students would provide an incentive for both to find other means for commuting to campus.

CHAPTER 7 – FOOD SERVICES

The large number of food distributors on campus makes this sector difficult to evaluate. Few changes have been made by either the eating clubs or the cash operations on campus, both of which generate large amounts of organic and inorganic waste. The Department of Dining Services (DDS) has improved some policies under the guidance of Stuart Orefice, the new director. The opening of the new Frist Campus Center in Fall 2000 is changing dining patterns on campus. Increasing bulk procurement, recycled and reusable goods, and disposal methods will reduce the amount of waste generated by food services on campus. DDS is the only food distributor on campus over which the University has direct control, so improvements must begin here. If successful, new procedures are likely to spread to the other facilities.

CHAPTER 8 – SOLID WASTE AND RECYCLING

Significant improvements in the recycling program since 1995 have been of great financial benefit to the University and have decreased its environmental impact. Though the structural recommendations of the PERC audit were not accepted by the University, the broad recommendation of improving awareness of the recycling program was observed to some degree. Continued efforts to increase student and faculty involvement in recycling on campus and to encourage the use of reusable materials would substantially increase the savings generated from this more ecologically sound method of disposal. The janitorial staff should also observe stricter enforcement of recycling policies. Savings in landfill avoidance costs would be enhanced by appointing a recycling coordinator to expand and monitor the program.

CHAPTER 9 – TOXIC AND RADIOACTIVE WASTE

This chapter includes data on metals, biological waste, chemical waste, and radioactive waste. Disposal quantities and costs have gone down in all four areas since the 1995 audit, due primarily to the efforts of the Environmental Health and Safety Office. External government regulations and the high cost of disposal force the University to deal responsibly with its toxic and radioactive wastes. Most of the policies in this sector will continue to be decided externally, so it is up to the on-campus producers of these wastes to ensure that proper records are kept and standards followed in accordance with government and University regulations.

CHAPTER 10 – ACADEMIC OPPORTUNITIES

The recommendations in the 1995 audit have been addressed well over the past few years: diversifiying the Environmental Studies Program (ENV) course

offerings, improving the core courses, and advertising job and funding opportunities to students. An array of cross-listed courses has expanded the diversity of ENV course offerings, representing collaborations between ENV and the Departments of Economics, Geosciences, History, Religion, Civil and Environmental Engineering (CEE), and the Woodrow Wilson School (WWS). Improvements to the Environmental Studies core courses seem to have attracted more students, and enrollment has begun to rebound from a downward trend since 1991. More extensive advertising of environmental job and research opportunities and of the Environmental Studies Program in general would encourage more students to enroll in the courses and in the certificate program. Further improvements should be made to the core courses, ENV 201 and 202, through the close cooperation of PEI faculty and by careful evaluation of student preferences as expressed in course evaluations.

SUMMARY OF RECOMMENDATIONS

CHAPTER 1 - PROCUREMENT

- Implement a 5% recycled product purchasing standard
- Establish a uniform set of environmental criteria to be used in negotiating all purchasing contracts
- Increase use of recycled paper and use of paper with higher recycled content through increased communication among the major paper users on campus (Computing Information and Technology, Library Photoservices, and the Office of Printing and Mailing)

CHAPTER 2 - ENERGY USE

- Install efficient lighting fixtures in all buildings on campus
- Link all buildings to the Central Supervisory Control System
- Take preemptive measures during construction and renovation to minimize energy needs of new buildings
- Install student-controlled heating in dormitories to reduce energy wasted due to overheating
- Increase allowable payback period for energy-efficiency projects

CHAPTER 3 - NEW BUILDINGS AND RENOVATIONS

- Adopt a stringent, ecologically conscious construction policy
- Use alternative construction materials
- Adopt a set of environmental criteria (outlined in Chapter 1) in purchasing decisions
- Monitor construction waste disposal processes to minimize environmental impact and procurement and disposal costs

CHAPTER 4 - WATER USE

- Design, construct, and renovate buildings to minimize their cooling needs
- Retrofit old plumbing fixtures with new, water-saving devices
- Establish a water-use monitoring method that collects data by sector and makes it available to the user
- Increase conservation awareness among students and employees to reduce demand

CHAPTER 5 - GROUNDSKEEPING

- Reuse construction waste from small projects when possible
- Increase use of shade trees to reduce energy use in buildings
- Emphasize use of native species in landscaping plans and minimal pampering of vegetation to allow it to develop more naturally
- Establish more reunion sites and alternate sites more frequently
- Restrict vehicular access to grassy quads during check-in and check-out as well as during the year
- Further reduce pesticide use by pursuing alternatives and increasing manual weeding

CHAPTER 6 - TRANSPORTATION

- Centralize management of the University vehicle fleet and its gasoline consumption
- Increase the cost of parking for students and implement parking fees for employees

- Improve shuttle service between the graduate school and graduate housing
- Provide other incentives for carpooling and the use of public transportation
- Support the needs of cyclists and carpoolers, such as more bike racks and preferential parking

CHAPTER 7 - FOOD SERVICES

- Increase bulk procurement and the use of recycled and reusable goods
- Implement responsible disposal methods, such as recycling and the pig farmer program
- Focus on improvements to the Department of Dining Services, in the hope that these changes will spread to other campus distributors

CHAPTER 8 – SOLID WASTE AND RECYCLING

- Appoint a recycling coordinator whose responsibilities would include:
  - Expanding and monitoring the recycling program
  - Fostering greater faculty and student involvement in material recycling and reuse
  - Encouraging stricter janitorial enforcement of recycling policies

CHAPTER 9 - TOXIC AND RADIOACTIVE WASTE

- Keep thorough records of waste production and disposal methods
- Tightly monitor compliance with government regulations

CHAPTER 10 – ACADEMIC OPPORTUNITIES

- Continue to diversify the Environmental Studies Program (ENV) course offerings
- Further improve core courses ENV 201 and 202
- Increase advertising of job and funding opportunities for students

CONCLUDING RECOMMENDATIONS

- Conduct an environmental audit of the University every two years
- Improve record keeping in all departments to enhance ease and breadth of future audits
- Create a University Environmental Committee that includes administrators, departmental staff, faculty, and students
- Work to increase environmental awareness among students, faculty, and staff
- Establish a distribution requirement that will introduce environmental concerns into the mandatory undergraduate coursework

Acknowledgments

We would like to extend our special thanks to Janet Gruschow, Executive Director of the Princeton Environmental Institute (PEI). Without her guidance and constant assistance, the 2000 audit would not have progressed past its beginning stages. Professor Michael Celia, Director of the Undergraduate Program at PEI, and Dr. Jon Paul Rodriguez also provided valuable insight and direction. Michael E. McKay, General Manager for Plant and Services, Office of the Vice President for Facilities helped us navigate the numerous departments in Facilities and find the data necessary to complete the audit. Edward T. Borer, Manager of Mechanical Systems, of the Facilities Engineering Department inspired us with the enthusiasm and personal interest he showed in the audit. Leila Shahbender and Jim Consolloy were also particularly helpful along with all of the ENV 201 students who laid the groundwork for several of the chapters. And finally, thank you to Alice Calaprice, senior editor at Princeton University Press, for her work editing this document, and Carmina Alvarez, graphic designer at Princeton University Press, for the audit design.

Elizabeth (Liz) Bernier '02 and
Brooke (Kelsey) Jack '03

Chapter 1

PROCUREMENT

The University has continued to use "green-buying strategies" such as buying items in bulk, buying fully recycled items or those with some recycled content, and reducing or eliminating the use of toxic materials. Recycled paper use has increased in some offices but decreased in others, yet seemingly contradictory explanations have been offered for these opposite trends. However, these changes have occurred mostly on a small scale, resulting in relatively little overall reduction in the University's environmental impact. The main recommendations of the 1995 audit were not addressed, so they still comprise our main recommendations in the current one. Two primary improvements that should be made are (1) the implementation of a 5% recycled product purchasing standard, and (2) a uniform set of environmental criteria to be used in negotiating all purchasing contracts. Increased communication between the major paper users on campus (Computing Information Technology, Library Photoservices, and the Office of Printing and Mailing) could facilitate increased use of recycled paper and use of paper with higher recycled content.

INTRODUCTION

Princeton uses an immense amount of resources, from paper to cleaning products, in its daily operations. If the products were purchased with the goal of reducing their environmental impact, the results could have a significant positive impact. Products that can help the University reduce its negative impact on the environment and use its purchasing power to benefit the environment are those that save energy and produce less waste, therefore saving money in both utility and operating costs. With its large purchasing power, the University could contribute to the development of recycled product markets by increasing demand and consequently lowering their prices. Environmentally conscious purchasing decisions can reduce the amount of energy consumed, waste generated, and toxic substances used in daily operations.

DATA AND COMPARISONS

Data for this chapter were compiled from the Fall 1999 Environmental Studies 201 Procurement report and 1995 PERC Audit Procurement Section

as well as from interviews with directors and staff of the Facilities, Purchasing, and CIT Departments.

The University has continued to implement established "green-buying strategies" in purchasing decisions. Several steps have been taken toward the goal of reducing the University's environmental impact in addition to the policies that were already in place five years ago. However, the narrow scope of these changes has limited the reach of their positive impacts.

Paper Procurement

Paper use has decreased slightly or, in some cases, remained the same as in 1995, but few improvements have been made in the overall use of recycled paper. The three main paper users on campus are CIT, Library Photoservices, and the Office of Printing and Mailing. Recycled paper procurement has improved in some departments and regressed in others for various reasons. For example, almost half of the printers that CIT uses in computer clusters are unable to operate efficiently with recycled paper, so virgin paper must be purchased for them. Twenty percent of the University's paper expenditures were for recycled paper in 1999; expenditures from 1995 are unavailable for comparison.

Computing Information and Technology (CIT)

The computer cluster manager, Leila Shahbender, purchases paper and toner for the laser printers, computers, monitors, and printers in CIT-controlled clusters on campus. CIT continues to use recycled toner cartridges in its printers and recycles the used ones if they can be retrieved from the clusters. Mrs. Shahbender has been attempting to resolve the excessive paper-use problem noted in the PERC audit, which continues to the present. She runs "think-before-you-print" ads in the *Daily Princetonian* during the year encouraging students to avoid unnecessary printing. She also posted signs above cluster printers suggesting that cluster users print their drafts double-sided. Princeton Environmental Action is considering co-sponsoring a paper-use reduction campaign in 2001 with CIT. Currently, a feasibility study is underway for issuing printing accountability packages that will let students know how many pages they are printing and how many they have printed to date. This type of system has demonstrated success at other schools and is designed to raise awareness about paper consumption.

CIT computer clusters use three printer models: Hewlett Packard 4000 series (14 printers), Apple Laserwriter # 16/600 (8 printers), and Xerox N2125 (12 printers). CIT purchases printers that combine the best in performance, durability, and ease of repair. In addition to these standards, CIT considers several factors that reduce the printers' environmental impact, including double-sided printing capability, the ability to handle recycled paper, and the manufacturer's commitment to recycling toner cartridges. Because myriad factors determine a printer's overall quality, any purchase inevitably involves trade-offs. Accordingly, there are some important differences among these three printers. All three models use cartridges that may be collected and sent back to the manufacturer instead of simply being discarded. Xerox disposes of the cartridges in an "environmentally friendly" manner, whereas Apple and HP use the old cartridges to produce new ones. Another option is the refilling of the Xerox cartridges, but this service is unreliable at present. Mrs. Shahbender is attempting to develop a system to ensure that used cartridges are retrieved

and returned to the manufacturer, though she has been encountering some difficulties.

Another significant difference among the printers is their double-sided printing capabilities. Two of the three printer models used in the clusters have this function (HP 4000 series and Xerox N2125), but the Apple 16/600 does not. The default setting on the former two models is for double-sided printing, which has generated some complaints. But there have been more requests to have all printers set with double-sided printing defaults.

Recycled paper is another major issue that tends to provoke strong public responses. Fourteen of the cluster printers are Hewlett Packard 4000 series or 4050N series that are capable of printing double-sided and that use recycled toner cartridges; but they have not been able to use recycled paper without frequent jamming. Therefore, the former cluster manager switched back to virgin paper, which is slightly more expensive than recycled paper at $33.00 per carton (5,000 sheets), versus $31.50 per carton for recycled paper. These jamming problems may be independent of the paper used and may be caused by the high humidity in many of the rooms where printers are located. CIT plans to investigate the possible causes in the near future. Eight of the printers are Apple 16/600 series that cannot print double-sided documents but do accommodate recycled paper. Students seem to prefer the virgin paper over the recycled paper because of its shiny appearance.

CIT has decided to replace the Apples and failing HPs with the Xerox N2125 in 2001. This model has met CIT's performance, durability, and ease of repair criteria. It is also capable of printing double-sided pages and accommodates recycled paper without jamming frequently.

The PERC audit had reported that soy-based inks did not meet the required performance standards for CIT. There were no reports of further inquiries into this alternative to petroleum-based inks in the past five years. Research into recycled paper that is compatible with all of the cluster printers and recycled toner cartridges continues. This research has begun largely since the 1995 audit due to the initiative taken by individual employees.

Last fall, students from ENV 201 took a survey of one hundred undergraduates to determine how frequently students use cluster printers and how much they would print if they had to supply their own paper. Their results are summarized in Tables 1.1 and 1.2. The second question is an attempt to gauge how much paper use is unnecessary; the assumption is a student who is required to expend his or her own resources to buy paper would not use it

TABLE 1.1.
Q: "What is your frequency of using the clusters?"

Rarely	Occasionally	Often	Very Frequently
22%	33%	29%	16%

TABLE 1.2.
Q: "If you were forced to supply your own paper, would your usage decrease, remain constant, or increase?"

Decrease	Remain Constant	Increase
32%	63%	5%

TABLE 1.3.
Comparison of recycled content in paper from 1994 and 1999.

	1994	1999	Difference
Annual Giving letters (Domtar Plainfield Plus)	50% recycled 10% PCW	35% recycled	-15% recycled
University Bond Paper (Strathmore Renewal)	25% PCW	30% PCW	+5% PCW

wastefully. The survey reveals that almost one-third of the students surveyed were using cluster paper wastefully and that they would decrease usage if required to buy their own.

Printing and Mailing Services

The Office of Printing and Mailing serves the University's printing and mailing needs, from photocopying and desktop publishing to color printing and scanning. Previously responsible for most departmental copying services, this office is now moving away from those duties and focusing more on University publications such as brochures, flyers, applications, forms, and letters. Increased use of electronic communication has driven down the demand for text paper printing. Several improvements in recycled paper content have been made possible by technical improvements in the recycled paper on the market. Overall use has increased by 500,000 sheets, to approximately 15 million sheets annually, though this is a rough estimate due to the wide variety of paper sizes used.

According to reports by Fred Plank of this office, virgin paper is not used because it is difficult to find such paper on the market whose quality is better than the recycled products. Table 1.3 shows the modest improvement in recycled paper content since the 1995 PERC audit. Annual Giving letters were previously printed on 50% recycled, 10% PCW paper, but they were replaced with 35% recycled paper. The paper now used for Annual Giving letters, Domtar Plainfield Plus, is an extremely reliable, comparably priced recycled paper that is used for 80 or 90% of the Office of Printing and Mailing's work in high-speed printers, according to Mr. Plank. A new color copier, Xerox 2060, uses the only virgin paper still supplied to departments by the Office of Printing and Mailing.

Library Photoservices and Copy Paper

According to reports from Ted McLaughlin of this department, paper use has decreased by almost 20%, from 6 million sheets in 1994 to 4.9 million sheets in 1999, though the change was not prompted by any specific changes in policy that targeted paper use. The Hammermill Savings 10% post-consumer waste recycled paper in use at the time of the PERC audit is no longer produced and has been replaced by Boise Cascade virgin paper due to budget limitations. According to Mr. McLaughlin, this virgin paper is less expensive

than recycled paper alternatives. Attempts to charge less money for double-sided copies, as was recommended in the PERC audit, were explored and deemed unfeasible because the service contracts of the printers are based solely on the number of copies made.

Purchasing Department

When departments make requests for supplies, the Purchasing Department sends out a request for services on which various companies bid. The company with the best reputation, product, reliability, and lowest bid wins the contract. One of the PERC audit's main recommendations was that environmental criteria be included among the other criteria so that the University could consider the lifecycle environmental impacts of the items it was purchasing. According to Don Weston, the director of Purchasing, environmental criteria are used to the extent possible, and many of the products purchased by his department have some recycled material. He also reports that the Purchasing Department attempts to make recycled products available to the University community, but notes that they cannot force departments to use these products and some department representatives are unaware of this option.

Building Services

The director of Building Services, George Frierson, was recognized in the PERC audit for his efforts to purchase environmentally friendly products. He reduced the number of toxic cleaning products used, substituting them with non-toxic alternatives, and made an effort to purchase products with less packaging. Building Services purchases most of its paper products, including paper towels and bathroom tissue, from Scott Paper Company. The products purchased have a 10% recycled content. At the time of the PERC audit, equivalent 100% PCW recycled paper products were available at comparable prices through a company called Marcal, but not yet through Scott. The PERC audit's recommendation to purchase these totally PCW-recycled products was ignored, depriving Building Services of the opportunity to eliminate the purchase of virgin paper products.

Grounds and Maintenance

Grounds and Maintenance, the largest purchaser on campus, was reported in the PERC audit to be seeking ways of making more environmentally conscious purchases. At the time, they were in the process of switching from oil-based to latex paints as these became available on the market. This change minimizes the amount of volatile organic compounds emitted in the production of oil-based paints while also eliminating the cost of hazardous waste disposal necessitated by oil-based paint cans and leftover paint. Emergency exit signs are now powered by the cogeneration plant (see Chapter 2: Energy Use) instead of batteries, reducing hazardous waste disposal costs for batteries and increasing energy efficiency.

Chlorofluorocarbons (CFCs) have been phased out, except in walk-in coolers, and were replaced by hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs), which have no chlorine and only 0.04% chlorine, respectively. This change has both reduced the University's CFC emissions, the chemicals responsible for ozone layer destruction, and increased energy efficiency in cooling systems, thereby reducing energy consumption. In addition, these alternatives can be

used in existing cooling systems so they do not require system overhauls.

There have not been reports of any serious attempts to reuse cardboard instead of recycling it, as was recommended in the PERC audit. Furthermore, cooperation with Habitat for Humanity to reuse old doors, sinks, faucets, and the like, has not been established. Technical incongruities, such as the fact that old doors are slightly smaller than the current door-frame standards, make it difficult to reuse these supplies. Another recommendation of the PERC audit, to store and resell old materials at discounted prices, has received little attention. The problem with this suggestion was the large amount of storage space that it would require; furthermore, there may have been technical difficulties similar to those encountered with the Habitat for Humanity project.

ASSESSMENT AND RECOMMENDATIONS

One of the most pervasive problems with attempts to reduce resource consumption and increase the use of recycled products is the University's lack of a uniform environmental policy in these areas. A concerted University-wide effort would surely be a more effective way of making progress in product reuse and use of recycled products. Though the efforts of individuals in some departments, such as those by the cluster manager at CIT, are helpful, they alone cannot achieve the far-reaching changes that are necessary to improve the University's sometimes environmentally negligent procurement habits. A strong commitment needs to be made along the lines of the PERC audit's recommendations to reduce environmental damage, establish Princeton as an environmentally progressive institution, and potentially generate savings. The University has the exciting potential to be a leader by making environmental preservation and minimal impact top priorities in its policies and operations. This policy should include two provisions: a 5% purchasing criterion for recycled products, and a set of environmental criteria to be applied to all purchases.

A 5% purchasing criterion for recycled products would require that recycled versions of currently used products be purchased when they are available at prices within 5% of the cost of nonrecycled products. When implemented, this policy should include existing contracts as well as future ones. Since the University purchases so much material annually, its increased patronage of recycled products will contribute positively to the market and perhaps help bring down the cost of recycled goods. If coupled with a reduction in consumption, especially with regard to paper, the extra costs of this policy could be met. Many other universities, such as Rutgers and the University of Washington, have adopted this standard, demonstrating that it is feasible.

A uniform set of environmental criteria should be applied to all purchases that the University makes to reduce the environmental damage caused by University purchases. Each purchase should be evaluated based upon the criteria listed below in addition to current contract specifications so that environmental consciousness can be incorporated into purchasing decisions while high-quality services are maintained. Some trade-offs may be necessary in attempting to meet the following criteria, in which case the product or services that meet the most guidelines while providing the best service should be chosen. Several organizations, including the Certified Forest Products Council, certify

sustainably harvested and sustainably grown wood and wood products. A commitment to environmental criteria would prevent the University from contributing to the harvesting of old-growth forests and the clearing of tropical rainforests while also raising awareness of these issues.

Environmental Criteria

1. Long-life and reusability
2. Minimal dyes (i.e., purchase less colored paper)
3. Minimal packaging: choose vendors who minimize packaging, reuse packing materials, and use packaging (e.g., cornstarch peanuts) that can be composted instead of sent to a landfill
4. Meet Energy Star Program criteria (see Chapter 2: Energy Use)
5. Certified Wood (i.e., sustainably harvested, sustainably grown)

Paper Procurement

CIT Computer Clusters

An investigation should be undertaken to determine the factors that cause printers to jam frequently and if recycled paper contributes to this problem. CIT should also continue to stay abreast of new products, such as printers, that may better address all of the performance criteria. Furthermore, the cluster manager should investigate the recycled paper on the market and test new varieties to see if improvements have been made that may increase its compatibility with printers. Current trends in CIT, including the replacement of Apple 16/600 printers with Xerox N2125, will likely help conserve resources and minimize an environmental impact in the long term and should therefore be encouraged.

Paper use in the clusters accounts for a significant portion of the University's total paper use, approximately 10% of the 50 million sheets of paper used annually. Consumption reduction campaigns should continue and be expanded, especially during peak paper use times like Dean's Date and final exam periods. The printing accountability package will be an invaluable tool in reducing paper consumption and should be pursued. Partnerships with student groups, such as the one being forged with Princeton Environmental Action, should be more widely pursued to encourage student involvement in fostering more efficient paper use.

Library Photoservices and Copy Paper

It is recommended that this department investigate recycled paper options because both CIT and the Office of Printing and Mailing have found recycled paper that is cheaper than virgin paper. This apparent incongruity may be because Library Photoservices orders paper from Boise Cascade, the company with which the University has a contract, whereas the Office of Printing and Mailing orders paper from a variety of other providers.

CIT Printing and Mailing Services

The Office of Printing and Mailing should continue to use recycled paper and investigate the availability of paper with higher recycled content. As the recycled paper market grows due to the increased patronage of large customers like the University, prices will decrease and companies will expand their options to accommodate their large customers. Perhaps paper with higher recycled content will become more readily available. With regard to soy-based inks, it is recommended that new

products on the market be tested periodically to determine whether they meet the required performance standards.

Purchasing Department

Building Services

Provided that these products are available at prices within 5% of current products, the contract with Scott Paper Company should be reopened so that the 100% PCW paper products may be substituted for current 10% PCW products. If they are not available through Scott, the University should explore a contract with Marcal Company, which does offer them. The availability of comparably priced recycled products is a wonderful opportunity for the University to reduce its impact without substantially increasing its overall expenditures.

The breadth of products purchased from Boise Cascade that are recycled and made from alternative materials should be expanded. Efforts should be made to investigate the availability of recycled versions of supplies as they become available. Large contracts that have been negotiated for supplies that are purchased frequently, such as file folders, should be negotiated as well for recycled versions of these supplies when they are available. This setup brings the price of products down even further because they are purchased in bulk, making recycled products price-competitive with nonrecycled ones. Currently, many virgin products are available at lower prices because of bulk purchasing agreements, making recycled products appear more expensive in comparison.

Grounds and Maintenance

Environmentally conscious purchasing decisions should continue. Overall, this department is doing a good job of incorporating such practices into its daily operations.

REFERENCES

Facilities Department: Jim Consolloy, Mike McKay, Tom Nyquist, William Traubel

Purchasing Department: Don Weston

Computing Information Technology: Leila Shahbender, Fred Plank, Ted McLaughlin

PERC Audit Procurement Chapter: Karen Thomas '96, Anne-Lise François GS, Rick Curtis — Assistant Dean of Students, Tommy Carr '98

Chapter 2

ENERGY USE

Energy use at the University has undergone a dramatic transformation since the 1995 audit due to the construction of a cogeneration plant to meet electricity and heating needs. Built primarily for economic reasons, this new facility has greatly reduced the University's environmental impact. Over the past five years, buildings have continued to be added to the Central Supervisory Control System (CSCS), a central computer that monitors heating and cooling in connected buildings. The University's demand for energy will continue to grow as the campus and student body expand. Installing efficient lighting fixtures and attaching all buildings to the CSCS will keep energy needs low. Heating of the dorm rooms should be individually controlled to eliminate wasted heat energy. Reassessing a pay-back period to allow more time for energy-saving projects or creating a special fund for "green" energy innovation should be priorities.

INTRODUCTION

Energy conservation can be translated into a reduction in the use of nonrenewable resources and the emission of pollutants. This can take the form of both "demand-side" reductions and energy production efficiency improvements. The rate of Princeton's energy consumption continues to increase steadily with the growth of the campus population and the addition of modern, energy-intensive facilities for research and instruction. However, the University has had a responsible track record for energy-efficient policies, which has improved dramatically since the time of the 1995 PERC audit. The majority of these changes have been results of the long-term correspondence between minimizing energy use and maximizing economic benefits.

The most significant measures for improvements in efficiency have been through the expansion of an energy management system, repairs and renovations to outdated systems, and the installation of a cogeneration plant for the University's electrical, heating, and cooling demands. Continuing on the current energy conserving and cost-cutting trajectory while increasing awareness of students and

employees will keep the University's energy use at a minimum.

DATA AND COMPARISONS

Much of the qualitative data on energy use was found in the 1995 PERC audit and the Fall 1999 ENV 201 Energy report. All of the information and computations for the cogeneration plant were provided by Ted Borer, Manager, Mechanical Systems, from the Facilities Engineering Department.

Energy Management

Central Supervisory Control System

In 1977, the University implemented the Central Supervisory Control System (CSCS), which consists of a central computer located in the MacMillan Building that is linked to remote buildings by underground cable, modems, and telephone lines. RMDMs (remote microprocessor data multiplexers) installed in each building transmit temperature readings, status of mechanical equipment, and steam, chilled water, and electrical meter readings to the central processing computer. Based on computer programming, this data can be used to control the starting and stopping of mechanical equipment, time of day scheduling, and the optimal start time calculations. For example, the system can calculate the appropriate time to turn on air conditioning, so that offices are sufficiently cooled by the time employees arrive. CSCS also monitors equipment maintenance, providing a warning when a specific piece of equipment needs servicing in order to continue optimal performance. The system cost $3 million to install and had a three-year payback period, at a savings of $1 million per annum. Most conservation projects require a payback period of four years or better.

At the time of the 1995 PERC audit, 73 out of 278 campus buildings (~26%) were connected to the CSCS. During the initial implementation, buildings were selected based on energy use; thus, most academic, administrative, and recently renovated buildings were a part of the system. Forbes College was the only dormitory on the system because of the limited potential for savings through the inclusion of other dormitories.

Since 1995, all new buildings and renovations have been incorporated into the CSCS. The number of buildings on the system is currently (Fall 1998) at 98 out of 326 buildings on campus (30%), representing an increase of 4% in the portion of total buildings attached to the system in the three years following the original audit. As renovations and construction continue, all dorms and most other buildings will eventually be incorporated into CSCS. All buildings that are not currently a part of CSCS are controlled individually by users or management through electric or pneumatic thermostats, a fairly inefficient process.

Technological advancements are allowing for constant improvements in the effective and efficient management of energy. Smaller on-site monitoring units have enabled control all the way down to individual thermostats. Increased networking capabilities through the development of Ethernet on campus have allowed CSCS to implement a bidding process to vendors. Competitive bidding among potential vendors (Carrier and Siemens being the primary vendors) has become possible though the integration of various systems into the network. Installation of additional occupancy detectors is helping to increase efficiency in CSCS-controlled buildings.

Computing

Energy Star

At the time of the 1995 audit, the Environmental Protection Agency (EPA) had recently released its Energy Star program for computers. Compliant computers power down to 30 watts or lower when idle, representing a 45% decrease in energy usage. The PERC audit computed this to represent a savings of approximately $56 per computer per year. A conservative estimate of 10,000 computers on campus yields $560,000 in savings each year.

Currently, all computer equipment purchased by the University is Energy Star compliant. The change to Energy Star compliance has been an industry-wide alteration. Already over 90% of computers and monitors are made to conform to the EPA's standards. With the large increase in computer use since the last audit, these changes are indicative of substantial financial and energy savings for the University.

Lighting

In 1995, an electrical energy conservation plan had been in place for five years, yielding about $400,000 in savings per year. Most of this had come from upgrades in old lighting systems. The other significant energy-saving measure was the installation of motion and daylight sensors in many classrooms, auditoriums, and hallways, resulting in an approximate 50% reduction in classroom lighting and a 20–25% reduction in hallway lighting.

A six-part plan, established by the Engineering Department of Building Services, is currently underway to provide lighting that uses less energy, is more labor efficient, and is easier on the eyes. This will call for the phasing out of incandescent bulbs in favor of fluorescent and LED models. Potential energy reductions of up to 46% will result from these changes. Additional occupancy sensors in hallways, classrooms, and some residential areas have further reduced wasted electricity. The dormitories are not included in this plan because they are being retrofitted for fluorescent and LED model lights as they undergo renovation as part of the University's master dorm plan (all dorms to be refurbished within the next 15–20 years).

In 1997, halogen lamps were banned from dormitories. The elimination of these inefficient 300- or 500-watt lamps in favor of more efficient compact fluorescent or incandescent bulbs has resulted in a decrease in dormitory energy use.

Dormitory Inefficiencies

Heating

At the time of the PERC audit, the only dormitory on the CSCS was Forbes College. All other residential areas, as well as other spaces not connected with CSCS, were heated by steam or hot water systems. A minimum temperature of 68°F in the coldest part of the building during the winter resulted in the overheating of the rest of the building. Consequently, students often compensate for excessively high room temperatures by opening windows at night or when they are out of the room. Many dorms continue to be heated while unoccupied over winter breaks.

As a part of the 15–20-year cycle of the Princeton University Master Plan, all dormitories will be part of CSCS by 2020 and heat-regulated by computer. A trial year of individually controlled student rooms has been occurring in 2000–01 in Blair Hall.

Windows

The 1995 report discussed the inefficiencies of divided, single-paned, Gothic-style windows. A new type of weatherproof window that maintains the Gothic style has been installed with the renovations to Wright and Patton Halls. If the trials with these windows go well, they should be incorporated into the dorm refurbishment cycle.

Energy Production and Consumption

History

In 1923, a power plant was built at the southern end of campus to meet growing electricity and heating needs. With minor modifications and improvements, this system continued to operate until 1967, when the University switched from a coal-burning to oil- and gas-fueled energy in anticipation of stricter air pollution laws.

In 1995, when the PERC audit was released, three 30-year-old steam boilers provided heating from natural gas and #6 fuel oil, a very dense, dirty-burning oil. Electricity was purchased from PSE&G, where it is generated at around 26% efficiency from several types of generators.

Cogeneration[1]

The 1995 audit discusses the planned construction of a gas-turbine cogeneration plant to provide electricity, heating, and cooling to the University. The cogen plant began operation in 1996, using natural gas as fuel for a gas turbine-driven electric generator and utilizing its waste heat to provide heating and cooling to the University. Princeton's status as a facility with year-round heat and power needs has enabled it to take advantage of the benefits of cogen technology, taking responsibility and direct control of emissions by transferring their production site to the campus.

The cogeneration process begins by pressurizing natural gas, then injecting it into a simple-cycle jet engine, similar to that of a stealth fighter plane. The exhaust passes through a CO reduction system, then either up the ventilation stacks or into a boiler. Oxides of nitrogen (No_x) are also controlled with water injection. The boiler is part of a loop that circulates through campus, converting steam into heating used by the chilled water plant for cooling buildings. After completing the loop, the steam is reheated and recirculated.

About 1.5 million deka-therms of natural gas are used annually by the cogen system. The backup fuel is #2 grade oil, which is considerably lighter and cleaner than the #6 grade backup fuel used by the old boiler plant. Though the amount of gas purchased by the University has increased over 80%, this does not correspond with a proportionate increase in energy consumption. It is simply indicative of the transfer of the production of energy and emissions from a private power company to an on-campus facility. Table 2.1 shows that the overall thermal efficiency of the campus has increased by 7.8% as a result of the changes in the process of energy production. Thermal efficiency was calculated by dividing the total energy services delivered (taking variations in fuel efficiency into consideration) by the total amount of energy resources used.

The University must purchase a small amount of electricity during the year (down 85.3%) and ends up selling some (~4% of total generated) back to the power plant, occasionally at a financial loss. However, the overall monetary savings more than outweigh this minor cost.

[1] All descriptions of the cogeneration facility are taken directly from Ted Borer of the Facilities Engineering Department and from the 1999 ENV 201 Energy Report.

TABLE 2.1

Comparison of the pre-1996 boiler plant with the new cogeneration plant.

	1994	1999	% Change
Gas purchased (deka-therms)	274,000	1,588,000	+82.7
Oil purchased (gallons)	5,246,000	868,000	- 83.5
Electric purchased (kWh)	92,985,000	13,689,000	- 85.3
Electric sold (kWh)	0	3,985,000	+100
Electric generated (kWh)	0	91,946,000	+100
Energy resource use (10^6 Btu's)	260,216	1,836,004	- 18.8
Energy services delivered (10^6 Btu's)	1,108,089	1,042,211	- 6.3
Campus overall thermal efficiency (energy delivered / resources used)	49.0%	56.8%	+7.8%

Increased ability to monitor the emissions of pollutants at the site of power generation has allowed for improvements in reduction methods. The old power plant at the University was "grandfathered," meaning its emissions were not monitored. Upper limits on SO_X, NO_X, CO_2, CO, VOCs, and particulates are now set by the New Jersey Department of Energy and Power (NJ DEP).

ASSESSMENT AND RECOMMENDATIONS

Energy use policies and systems have improved drastically since the release of the PERC audit in 1995. Approached from both the demand and production ends, efficiency increases have reduced both the University's environmental impact and annual economic expenditure on energy. Ted Borer of the Facilities Engineering Department estimates that at least $40 million have been invested in energy-efficiency improvements since the first measures were implemented in the late 1970s. The University's generous endowment and budget have allowed long-term decision making that manages to be both environmentally and financially sound. The majority of these changes continue to be motivated by questions of cost, which tends, in the long run, to correspond with increases in energy efficiency.

CSCS

The short payback time for the implementation of the CSCS indicates its financial value, while the energy reductions it incurs signify its importance on an ecological level. The 1995 recommendation to continue to add buildings to the system has been fulfilled, though to a limited extent. The economic

inefficiencies of adding buildings that are not undergoing construction or renovation keep the expansion rate slow.

Computing

The industrywide conversion to Energy Star compliant computer equipment has reduced Princeton's energy consumption in the area of computing technology. The PERC audit suggested that energy efficiency under the EPA's Energy Star guidelines become a consideration in the University's procurement of computing technology. External changes in manufacturing have helped to fulfill this recommendation.

A campuswide policy to turn off computer monitors when not in use would certainly reduce energy consumption. There is currently no information on the portion of energy use for computing purposes. Such data, as well as a survey of student and employee computer use, might be helpful in determining the necessity and feasibility of any changes in this area.

Lighting

Ongoing changes in lighting systems are helping to reduce energy consumption in this area. These improvements are mainly a result of technology increases that save money and improve quality and efficiency. Continuing to upgrade old systems and install occupancy sensors will continue the decreases in energy use and financial expenditures.

The primary room for improvement lies in the education of students and staff. Encouraging students to use more energy efficient lamps in dormitories and to turn off lights when they are not in use will help curb the waste of electricity. The same recommendations can be applied to employees.

Dorm Inefficiencies

The long-term Master Plan, calling for the renovation of all dormitories by the year 2020, will result in significant improvements in heating and insulation. Allowing dorm room temperatures to be individually regulated would prevent students from compensating for overheating in the winter by opening windows and wasting considerable heat energy. An upper limit on the thermostat would eliminate the possibility of carelessness or wastefulness on that end. Continuing to explore options related to climate control will improve future options.

Energy Production and Consumption

The installation of the cogeneration plant has resulted in enormous improvements in energy efficiency for the campus. This brilliant example of economic advantages allying with improvements in environmental impact should serve as a role model to other universities and corporations across the nation. As a result of the implementation of the new plant, Princeton is already compliant with the terms of the Kyoto Protocol established at the 1997 Earth Summit, which would call on industrialized nations to reduce carbon emissions to 7% below 1990 levels by the year 2010. In spite of the addition of over 160,000 square feet of building, Princeton's weather-corrected energy use is currently 7.3% below what it was in 1990, with a 7.4% increase in overall thermal efficiency since the time of the last audit. The switch from coal and #6

oil to natural gas as the energy source adds an additional carbon emissions reduction of approximately 30%. Further calculations will reveal an accurate figure for the actual emissions reduction since 1990. In all likelihood, the University will still fall well within the range of a 7% cut in 1990 emissions in the year 2010.

Such improvements in efficiency as introduced through the cogen plant cannot be expected to continue. The University should, however, continue to exploit cogeneration or the use of other highly efficient equipment to meet the expansion of energy needs. A Thermal Energy Storage system has come under recent consideration by the administration. Producing cold water at night and storing it for cooling use during the day would allow chillers to be run more efficiently, which would in turn reduce the amount of electricity bought by the University during peak hours during the summer when utility generation is least efficient. Though the large cooling building that the system demands is esthetically unpleasing, it would contribute substantial energy savings, resulting in economic and environmental benefits. As air conditioning capacity is expanded to an increasing number of buildings, the vast energy and water resources that it demands must be addressed.

The University should consider expanding the allowable payback period for energy-saving projects. A fund for “green” energy would allow such projects to go ahead without placing stress on the additional financial sources for energy development on campus. Additionally, focus should be placed on demand-side management, creating and implementing efficient systems, so that increases in energy consumption are kept to a minimum.

REFERENCES

Department of Engineering, Facilities: Edward T. (Ted) Borer

ENV 201 Energy Report: Whitney McDowell ’00, Evan Variano ’00, Lindsay Warner ’01

PERC Audit Energy Use Chapter: Lucinda Shih ’95, Christopher Jones ’95, Agnes Shin ’98

Chapter 3

BUILDING DESIGN AND RENOVATIONS

Several specific efforts have been taken since 1995 to use green architectural principles and to recycle materials with the goal of lowering the operating costs of all buildings. The University continues its practice of recycling old buildings whenever possible to conserve resources. The 1995 PERC audit had suggested that the University utilize the new wave of construction, including the new campus center, to adopt a stringent, ecologically conscious construction policy. However, the University has yet to address this recommendation, partly because each project has unique demands. Nonetheless, the University should develop an environmentally conscious construction and building policy to minimize the environmental damage caused by new buildings and by renovations.

The entire construction waste disposal process, with one notable exception, is left to individual contractors and is expected to be carried out in the cheapest way possible. We reiterate the 1995 audit recommendations that alternative construction materials be used when possible and that a set of environmental criteria (outlined in Chapter 1) be applied to construction material purchases. Due to its large environmental impact and the potential to apply environmentally sound practices, the construction waste disposal process should be monitored by the University with the goal of reducing its environmental impact and the University's procurement and disposal costs.

INTRODUCTION

Since 1995, the Facilities Department has sponsored the construction of Scully Dormitory, the McDonnell Physics Building, the Stadium and Weaver Track, additions to Caldwell Field House, 262 Alexander Street, Schultz Hall Molecular Biology Building, the Woolworth Music Center addition, the Frist Campus Center addition to Palmer Hall, Wallace Building, an addition to the boathouse, and several major renovations including Patton and Wright Halls. The University has also implemented its 100-Year Plan that provides for the complete renovation of one building a year for a one-hundred-year period. A large parking garage was recently completed and the Genomics Institute is in the beginning stages of construction as well.

Architects and engineers for new buildings and

major renovations are generally interviewed by representatives of the Office of Physical Planning, Facilities Engineering, the Maintenance Department, and the user group — i.e., the group for which the building is being built. Ad hoc committees representing these groups routinely recommend specific consultants to be hired and periodically review the plans and the progress of building construction to ensure that the project proceeds smoothly. Building design must comply with local and state building codes. A major change in these codes has occurred since the PERC audit: air intake amounts regulated by ventilation codes were increased. In the 1970s, state regulations restricted the amount of air that could be taken into buildings for ventilation in an attempt to reduce energy costs. However, this level was deemed impractical because it was too low, so it was raised again.

Provided that they comply with public building codes, design decisions are based on the primary goal of minimizing operating costs for the building and meeting the needs of the user group. Environmental considerations are not a primary objective, but they are addressed if they are found to be cost-effective.

DATA AND COMPARISONS

Data for this section was compiled from Fall 1999 ENV 201 Green Building Report and 1995 PERC Audit New Facilities chapter as well as from interviews with directors and staff from the Office of Physical Planning and Building Services.

The Office of Physical Planning continues to devote its resources to the recycling of old buildings, which is a highly efficient way of facilitating new growth in an ecologically sensitive manner. When it is not possible to recycle buildings and new materials must be used, efforts are made to recycle these materials and to apply green architectural principles as much as possible within budget limitations. Furthermore, because buildings are designed to last for several hundred years, the most durable materials are used to minimize their replacement during the building's lifetime. Twenty new buildings in design or currently under construction have incorporated these guiding principles. The major benefits of this approach are that all minimize the impact on central utilities, the requirement for vehicular circulation, and the need for replacement materials.

The Office of Physical Planning also has a working relationship with researchers on campus who are developing technology that could be used to lower operating costs or improve efficiency. Mike McKay, General Manager for Plant and Services, Office of the Vice President for Facilities, and Tom Nyquist, Director of the Engineering Department of the Office of Physical Planning, report that they are attentive to research and development on campus, such as the work of Electrical Engineering professor Sigurd Wagner with solar cells. They attempt to incorporate into their operations when possible new technology from departments such as Chemistry and the School of Engineering.

Building Design

Structural Considerations

Green architectural principles are being applied as part of a general approach to lower building operating costs. The potential energy-saving and structural aspects of buildings constructed on campus are proposed by the architects unless specific requests are made by the user group or the Facilities Department. The selection of an architectural firm

is undertaken based on the criteria of reputation, reliability, and experience with similar projects. Architects are presented with the general guidelines for the desired building, including specific requests from the user group and a budget, and the architect designs the building. The committee evaluates the proposed design and makes changes as it sees fit. Architects sometimes present plans for innovative energy-saving mechanisms that are evaluated on their cost-effectiveness, functional and esthetic value, and user-group preferences. Features of buildings are generally required to provide a three-to-five year return on the University's investment. An example is the triple-paned window design proposed for a building with a large glass wall, which would have resulted in increased insulation and reduced energy use. This proposal was rejected because it was not cost-effective.

According to Jon Hlafter, Director of the Office of Physical Planning, the Frist Campus Center and the planned Genomics Building have incorporated green architectural principles into the building designs. The new campus center provides a unifying interior space that overlooks a new lawn that was once a parking lot. The architects, Venturi Scott-Brown, prepared a report on how principles of "green" design might best be applied and subsequently based their design decisions, including exterior design, on that report. Architect Rafael Vinoly, who also designed the new football stadium, is exploring solar-sensing techniques for the Genomics Institute. These techniques would shade the south-facing glass wall of the building to minimize heat gain in a space where the need for artificial lighting during the day should be largely eliminated, thereby drastically reducing energy use. The possibility of building a highly energy efficient building in the next few years for the Princeton Environmental Institute is also being explored.

Energy-Conservation Measures

Motion-sensing automatic switches are now required on all major projects, although they are sometimes resisted by the faculty. Many other energy-saving specifications are required by Facilities Engineering. Efforts are also being made to provide better lighting in student rooms because the light provided is often insufficient, prompting students to bring in lamps and floor lighting. These lighting implements are usually less efficient than the lighting that could be installed by the University. Over the last 10–15 years, old incandescent lighting fixtures throughout the campus have been replaced with compact fluorescent lights that are far more energy efficient. Exit signs located above all doorways were refitted with smaller bulbs that use less energy.

Fume hoods in laboratories are the largest single energy-consuming feature of buildings on campus. They are required to keep dangerous fumes from escaping into the interior of the lab and harming people. Controls are built into these hoods so they can be shut off when not in use to minimize excessive energy use. Furthermore, heating coils transfer heat from the hoods' exhaust air to incoming air, thereby preheating it slightly and reducing energy consumption.

The Heating, Ventilation, and Air-Conditioning (HVAC) system is run by a central computer that adjusts heating and cooling needs as appropriate to ambient temperatures. The HVAC system controls the temperature in most of the older buildings and dorms on campus, but some of the new buildings, such as Scully, have thermostats in each room so that students are able to control

room temperatures themselves. It is difficult and expensive to install individual thermostats in the rooms of old buildings, so that option is often not pursued. Buildings constructed in the future will incorporate this feature into their design when possible. A highly efficient ventilation system was built into Scully Hall that captures heat from exhaust air before it is expelled from the building and transfers the heat to the incoming air. This heat recovery system reduces energy consumption and will also be used in the Genomics Institute.

Construction Materials

Procurement

Vendors of construction materials are chosen based on their reliability, price, and service, with preference given to companies used before. Whether or not the materials purchased are obtained or manufactured in the most environmentally sound ways is not a consideration. The University uses the most durable and long-lasting materials so that they do not have to be replaced. Natural materials, such as cut stone instead of cast stone, are used frequently in place of manufactured materials because they last longer. Recycled wood is used when a particular type or cut of wood is needed to decorate a building's interior if it is cheaper to purchase used than new.

Disposal

When the new football stadium was built, over 40,000 cubic feet of crushed concrete was reused in off-campus construction projects such as road resurfacing in which crushed concrete is a base. This effort was demanded by a trustee rather than undertaken on the Facilities Department's own initiative. In general, the construction waste from most construction projects on campus is not handled by the University but by the individual contractors of each project. Therefore, the University's involvement in the recycling of concrete from the old stadium was a unique occurrence.

ASSESSMENT AND RECOMMENDATIONS

There have been no significant changes in University policy with regard to new buildings or renovations as suggested by the PERC audit. The audit had recommended that the University use the new wave of construction, including the new campus center, to adopt a stringent, ecologically conscious construction policy that would achieve the following three primary objectives: (1) allow the University to operate more efficiently, (2) promote proper ecological awareness, and (3) raise Princeton's status as an ecologically aware institution. More general suggestions included the adoption of a clear environmental building policy that would take construction as well as design into account. Since 1995, several new buildings have been built and green architectural principles were incorporated where they were deemed cost-effective. The general approach to new buildings that the University takes is extremely environmentally conscious with regard to energy efficiency, durability of new structures, and recycling of old buildings. However, the environmental impact of other aspects of new construction is generally not considered and often not even monitored.

Building Design

Green architectural principles are being applied when they are cost-effective. Architects are not

evaluated for their expertise, nor are these principles necessarily considered in building design. To ensure the minimum environmental impact of new buildings and renovations, the Facilities Department should hire a green architectural consultant to oversee building design or adopt an environmental building policy that would ensure the use of green architectural principles. Either or both of these measures would further encourage the use of the least environmentally damaging methods in all new construction projects. The current process for building construction does not make a commitment to ensure the utmost environmental integrity of its projects, though these issues are addressed to a great degree in some projects. If a commitment to minimizing environmental impact were made and followed, the University could further reduce its operating costs overall, minimize its ecological damage, and establish itself as an environmentally progressive institution.

Construction Materials

Procurement

The University currently does not attempt to procure recycled materials or apply environmental criteria to its construction materials purchases, as is true of the rest of its purchases. Vendor contracts should be negotiated with environmental criteria in mind. The criteria outlined in the Procurement section of this audit (Chapter 1) should be applied to construction materials as well as other University purchases. The PERC audit had recommended alternative construction materials that could minimize the harmful ecological effects of construction. These materials, such as carpeting made from recycled plastics, are often cheaper than virgin materials, and the University's purchasing power could aid in the development of markets for recycled construction materials.

Disposal

Every effort should be made to recycle and reuse construction waste instead of sending it to landfills. The University does not normally monitor the disposal of materials as long as contractors do it cheaply and legally. The one notable exception to this policy was ordered by a trustee and is an excellent example of how a policy that promotes reuse and recycling could have large immediate impacts. A disposal process monitored by the Facilities Department would generate some idea of the total amount of waste being generated and how better to reduce this amount and the ecological damage it causes. Perhaps materials could be reused on campus, reducing expenditures for virgin materials. This aspect of the construction process should not be left up to contractors whose only criterion in deciding how to dispose of large amounts of construction waste is to minimize their cost. The University should monitor the disposal of construction wastes in order to maximize recycling and reuse of materials as well as instruct contractors to consider these goals when making disposal decisions. Additional staff would have to be hired to monitor the construction waste disposal process.

REFERENCES

Office of Physical Planning, Facilities: Mike McKay, Tom Nyquist, Jon Hlafter

Building Services: Jim Consolloy

ENV 201 Green Building Section: Emily Atwood '00, Emily Poe '01, Graham Elliott '01

PERC Audit New Facilities Report: Joe Faber '97, Brett Dakin '98

Chapter 4

WATER USE

Records of water use on campus are taken from monthly water meter readings and are kept by the Business Office in a random manner, making them inaccessible for analysis. Water use on campus has increased in almost all sectors since the time of the 1995 audit. The largest increase in demand is due to the installation of air conditioning in new and renovated buildings. General campus expansion has also significantly increased the University's water needs. As new construction and renovations occur, old plumbing fixtures are replaced by more efficient ones. Economic concerns have helped inspire the push to conserve water through the installation of such devices, as well as making improvements in cooling efficiency by connecting buildings to the Central Supervisory Control System. Preemptive measures to reduce cooling and water needs will result in more efficient new and renovated facilities. Monitoring water consumption by sector through the Business Office will allow assessment of changes in water use due to policy improvements. Raising student and employee awareness of water use may be the most cost-effective method for reducing demand.

INTRODUCTION

Only 0.01% of the world's drinkable water is readily accessible, making preservation of this nonrenewable resource a pressing ecological concern. While inarguably environmentally significant, water conservation can also have economic benefits. The University has begun to capitalize on this dual benefit by installing low-flow bathroom fixtures, which held primary responsibility for a reduction in total water use in the undergraduate residential sector between 1996 and 1999. The call for improvements in efficiency will grow as the University continues to expand, adding more buildings, facilities, and acreage and increasing overall water demand.

Improving the efficiency of water use by the University and increasing student and employee awareness of water consumption are two of the most promising means for reducing both environmental impact and economic cost related to water use. This chapter outlines some of the measures that can be taken in this direction and examines changes in policies and practices since the release of the 1995 PERC audit.

TABLE 4.1.

Water use by sector (in millions of gallons).

	1996 (% total)	1999 (% total)	Change	% Change
Residential	76.63 (30.6)	76.31 (31.0)	- 0.32	+.4
Undergraduate	73.59 (29.3)	71.39 (29.0)	- 2.2	- 0.3
Graduate	3.04 (1.2)	4.92 (2.0)	+1.88	+0.8
Administrative	6.92 (2.8)	7.38 (3.0)	+0.46	+0.2
Athletic	21.13 (8.4)	29.54 (12.0)	+8.41	+3.6
Academic	80.57 (32.1)	54.15 (22.0)	- 26.42	- 10.1
Science	69.45 (27.7)	41.85 (17.0)	- 27.6	- 10.7
Non-science	11.12 (4.4)	12.31 (5.0)	+1.19	+0.6
Maintenance	62.88 (25.1)	78.77 (32.0)	+15.89	+6.9
Refrigeration	23.48 (9.4)	49.23 (20.0)	+25.75	+10.6
Miscellaneous	2.70 (1.1)	0.01 (~0)	- 2.69	+1.1
Year total	50.83	246.16	4.67	

DATA AND COMPARISONS

Aggregate Water Consumption by Sector

The 1995 PERC audit did not examine University water consumption by sector, so data records were accessed to provide a basis of comparison for current information. The records closest to the timing of the PERC audit that were also readily available were from 1996, so the comparison is over only a three-year period, using data supplied by the Business Office.

Water meter readings are taken monthly or twice monthly from most buildings on campus. The residential section is broken down into two categories: undergraduate dormitories and graduate housing. Included in the administrative section are all buildings such as New South and Nassau Hall that cannot be classified as academic, athletic, or maintenance. The miscellaneous category includes buildings such as Murray-Dodge and the Center for Jewish Life, which provide student services that are not considered academic or athletic. Engineering buildings fall under the classification of Academic Science. The substantial amount of University water that is used for cooling purposes calls for the creation of the subcategory of Refrigeration under Maintenance. No off-campus buildings are included in the data. Because the classifications are not applied to the original data as recorded, and the classification of buildings for the 1996 data and the 1999 data was done by different people, some mi-

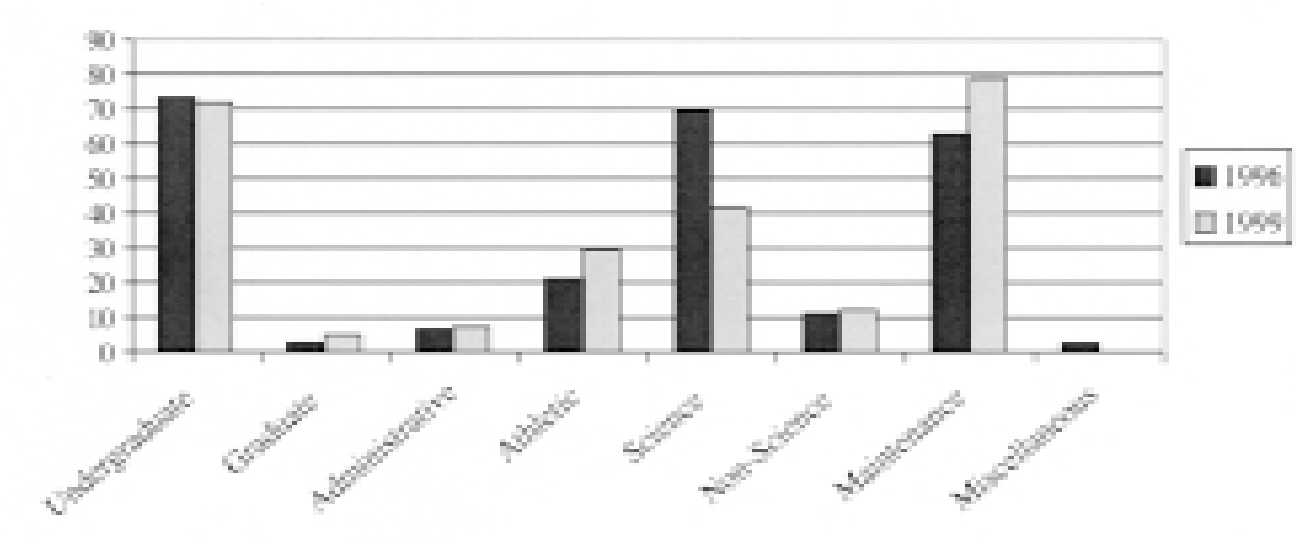

Figure 4.1. Water use by sector (in millions of gallons).

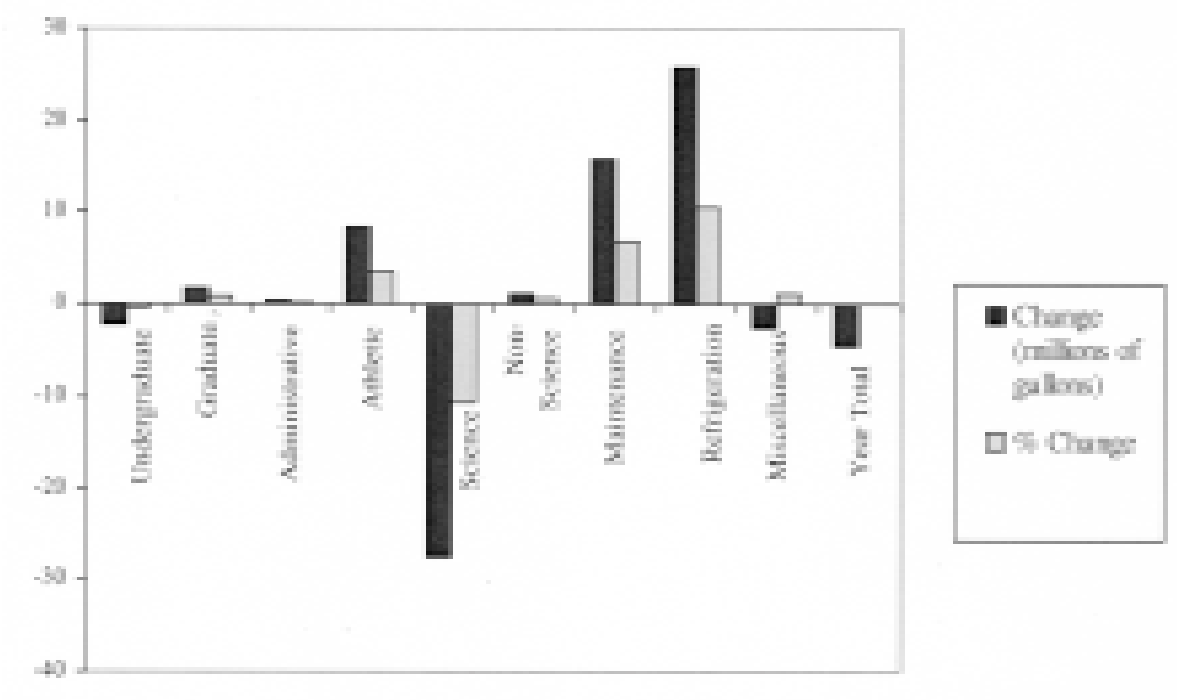

Figure 4.2. Changes in water use by sector.

TABLE 4.2.
Survey on undergraduate residential water use.

	1994	1999 (undergraduate)
What is your average shower time per day?	12.5 minutes	11.9 minutes
Gallons consumed in this time	41.1 gallons	29.75
Are you conscious of the amount of water you are consuming when using bathroom facilities?	70% YES	65% YES
Do you turn off the water while brushing your teeth?	70% YES	75% YES
What would you guess is the amount of water you use in the shower each day?	26.4 gallons	48.5 gallons

nor discrepancies may have resulted from differing subjective interpretations of appropriate building category.

The total amount of water used by the University dropped by 4.63 million gallons between 1996 and 1999. In Figure 4.2, it is apparent that this overall drop was primarily a result of a 27.6-million-gallon decrease (down 10.7% of the total) in the category of Academic Sciences. Further investigation is needed to determine the cause of that reduction, but most likely it is a result of a change in the data collection procedure — such as the exclusion of a major lab from this set of data — rather than a representation of any real decreases in water consumption. The inclusion of such a false decrease would skew the total numbers. Had the data for water use in the Science category remained the same between 1996 and 1999, the total water use would have increased by 22.93 million gallons instead of falling by 4.67 million gallons.

The largest increases in water use (25.75 million gallons) and percentage of total (up 10.6%) occurred in the category of Refrigeration in Maintenance. This increase represents the installation of air conditioning units into most new and renovated buildings. The minor decrease in Residential Undergraduate water use indicates the replacement of old toilets and showerheads with more efficient models as dormitories underwent renovation.

Residential Water Use

Residential water use accounts for 31% of the total campus water use and is an area easily modified through changes in practice, at a minimal economic cost. The replacement of old showerheads (3.29 gallons/minute) with new, water-saving fixtures (2.5 gallons/minute) has caused a minor reduction in residential water use (see Table 4.1 and Figure 4.1).

Student Survey

The 1995 PERC audit focused on undergraduate residential water use, conducting a four-question survey of thirty residents of Witherspoon Hall, an undergraduate dormitory that is part of Rockefeller College (see Table 4.2). The survey was repeated in the fall of 1999 by students from ENV 201, and questioned an expanded pool of students. A comparison of the results of the two surveys indicates changes in water use and attitudes over the past five

years in the student population.

The estimated shower time for undergraduate students dropped by 0.6 minutes, an insignificant amount considering the subjectivity of these estimations. However, when this minor change was factored in with the much larger reductions in water use resulting from the replacement of showerheads, consumption per student per day fell by 11.35 gallons (41.1 to 29.75). While the number of students claiming water consciousness has fallen by 5% since the earlier survey, the number of students who say that they turn off the water while brushing teeth has risen by 5%. This simultaneous drop in awareness and improvement in action seems to be contradictory, as does the reduction in estimated shower time coupled with the near doubling of estimated daily water consumption.

The small sample size may have contributed to the contradictory survey results, which should not be accepted as representative of the student body as a whole. The small decrease in water use in the undergraduate sector is a more accurate measurement of any changes in student behavior, though in this case it may merely be indicative of conservation resulting from the new bathroom fixtures.

ASSESSMENT AND RECOMMENDATIONS

As the campus has continued to expand over the past five years, water demands in most sectors have also increased. These rises in water use are combated by ever-improving technology for the conservation of water, such as low-flow showerheads and toilets. The University's efforts to implement such devices as older devices break and renovations occur have been motivated largely by economic concerns. Water use is an area in which minimization of cost tends to correspond with increases in efficiency. Evidence of this can be seen in the reductions of residential water use deriving from the retrofitting of most showerheads and many toilets on campus. Efforts to increase student and staff awareness will improve the demand-side of the problem.

Aggregate Water Consumption by Sector

The substantial increase in water use by Maintenance, specifically in the refrigeration and cooling sector, will continue as new buildings and renovations are constructed with air conditioning. Efforts to obtain the most efficient equipment and to attach all cooling devices to the Central Supervisory Control System (see Chapter 2: Energy) will help keep water use for this sector at a minimum. Incorporating considerations of ventilation into new building design (see Chapter 3: New Structures and Renovations) will diminish the need for artificial cooling, and concentrating summer occupancy will reduce the number of buildings that must be air conditioned. The other area that has incurred the greatest increases in water use over the past five years has been athletics. Expanding fields and facilities require substantial amounts of water for their maintenance. The University's reliance on athletics-motivated alumni donations eliminates the economic benefits of reducing water use in this sector.

The changes in content of the Academic Science category of the water use comparisons have rendered the change in total water consumption inconclusive. By examining the broader trends in use, it is reasonable to conclude that overall water use for the campus has increased over the past five years.

All data on water are kept by the business office, in the form of lists of monthly water meter readings of all of the buildings on campus. No data are compiled on use by sector, keeping the University unaware of the division of its economic and environmental impact through water use. Regular evaluations of the distribution and changes in water consumption by sector, along with the corresponding financial figures, would enable the University to place pressure on specific departments to reduce their water use.

Residential Water Use

The student surveys conducted in 1994 and 1999 shed little light on the actual nature of water use in the dormitories and housing at Princeton. Information on current student practices could help determine the areas of use with the greatest need and potential for improvement. Expanding the study and asking students to monitor their own water use over the span of a few days or a week would provide concrete, quantitative data from which more solid conclusions might be drawn. An examination of awareness levels will also help provide a starting point for the process of student education. Raising concern for water conservation among the student body is a relatively simple and cost-effective means for reducing University water consumption.

REFERENCES

Princeton University Business Office: Kathleen Moore

ENV 201 Water Use Report: Sarah Cobey '02, Anthony Loden '00, Joe Nuzzo '00

PERC Audit Water Use Chapter: Sarah Rollet '96, Sarah Finklestein '98, Graham Bullock '98

Chapter 5

GROUNDSKEEPING

Over the past few years, several changes have been made to enhance groundskeeping efficiency and further reduce its environmental impact. Among these changes are improvements to the Integrated Pest Management System and the hiring of a landscape architect to coordinate campus landscape design. Grounds and Maintenance recycles 100% of the organic waste, masonry, and metal waste generated on campus but not other construction waste such as wood and glass. We recommend that the reuse of construction waste from small projects be explored and that shade trees continue to be used to reduce energy use in buildings. Landscaping plans should continue to emphasize native species, and vegetation should be minimally pampered to allow it to develop more naturally. More reunion sites should continue to be added so that they can be alternated. Vehicular access to grassy quads should be restricted during check-in and check-out as well as throughout the year.

The pesticides section of the 1995 PERC audit is the only portion of the audit that corresponds to this chapter. Recommendations in that section included reducing use and investigating alternative herbicides to the reportedly carcinogenic ones used currently. Reductions have been made, but the most popular pesticide, "Roundup," is still in use. We recommend continuation of the efforts to reduce pesticide use and investigate less harmful alternatives such as manual weeding.

INTRODUCTION

The Grounds and Maintenance Department's responsibilities for campus grounds include the disposal of organic waste, upkeep of all vegetation, waste disposal from some construction projects, and management of the setup and cleanup for reunions. Most construction projects on campus are managed by independent contractors who are responsible for waste disposal, but the Grounds and Maintenance Department does handle waste from some on-campus construction projects. The topic

of groundskeeping was not covered under the PERC audit; the first report on the policies and practices of campus groundskeeping was compiled by students from Fall 1999 ENV 201. There are a handful of University policy changes that could minimize this environmental impact while saving money and making the entire operation more efficient. However, they are likely to meet a great deal of resistance from students and the rest of the campus community.

DATA AND COMPARISONS

Data for this chapter were compiled from the Fall 1999 ENV 201 Groundskeeping Report and the 1995 PERC audit's Other Areas of Impact chapter as well as interviews with the director and staff of the Grounds and Maintenance Department.

Since 1995, the Grounds and Maintenance Department has faced several statewide periods of drought. In addition to managing such temporary problems, construction and the replacement of aging and inadequate utilities requires ongoing attention. Construction damage and natural aging processes have necessitated the replacement of many of the campus's older shade trees. Furthermore, much of the flora on campus is vulnerable to pest infestation, especially exotic pests. These threats require careful management and treatments that may pose additional environmental hazards. The Integrated Pest Management (IPM) system developed in the 1920s is a highly efficient approach to all floral maintenance efforts on campus, and reduces the need for chemical treatments, thereby minimizing their detrimental environmental side-effects. The Grounds and Maintenance Department has improved the IPM system over the past five years and planned several projects to reduce paved parking lots, provide cooling to buildings with more shade trees, and reduce pollution of local surface water bodies from runoff.

Reunions

The University hosts this three-day celebration every year to welcome alumni and their families back to celebrate their experiences at Princeton. Attendance has continued to increase over the past five years, with 12,000 to 15,000 alumni and their families attending in 1999. This abundance of people takes its toll on the campus, especially the fragile grassy areas sensitive to soil compaction from trampling. Fifteen reunions are centered in courtyards around campus, each consisting of its own bandstand, tent, bar, and registration table. Setup begins well in advance of the event, and tents and stages remain standing for about three weeks. During this time, grass is covered and killed by reunion props that deprive it of sunlight, oxygen, and water. Reseeding is necessary across the campus after reunions, a feat that requires from 500 to 1,000 pounds of grass seed every year. Campuswide, grassy areas are reseeded a total of three times during the year: after reunions, after summer camps during the summer, and after students move onto campus in the fall. Annually, from 1,500 to 3,000 pounds of seed is used by these three main projects.

Three methods are currently used to protect grass during reunions to minimize reseeding. The first is the redesign of reunion layouts with the tables and bars placed next to paved walkways so that lines extend onto these paved areas instead of the grass. A pilot program of the second method, avoiding water runoff onto the grass, was imple-

mented at two reunion sites in 1999. Ice-filled containers used to cool beverages for the festivities leak melted ice onto the grassy areas, leaving them more vulnerable to detrimental soil compaction when exposed to vehicular and foot traffic. In 1999, Grounds and Maintenance pioneered the use of troughs equipped with pumps to collect runoff from these containers and to siphon it into storm drains. The experimental sites were so successful at mitigating the runoff problem that this practice was expanded to ten sites in the year 2000. The third method is the inclusion of a sixteenth reunion site so that the fifteen sites can be rotated each year, leaving one vacant site to recover. This pattern would allow the grass to firmly establish itself, making it more resilient in future years. Scully courtyard was the sixteenth site for the 2000 reunions.

Student-Related Impacts

Enormous damage to grassy quads is caused regularly as vehicles are driven over these areas for various reasons. The biannual student moving process, which takes place in early fall and late spring, causes significant damage to grassy areas as students and parents seek greater access to dormitory entryways. Pizza-delivery cars and package-delivery trucks continue the destruction of grassy areas during the school year, driving across quads to gain proximal access to dorms.

Foot traffic also does damage by wearing muddy shortcuts into otherwise healthy lawns. Grounds and Maintenance has sought to address this problem by paving these alternate pathways and by using a variety of tougher grass seeds, one of which is a turf athletic mixture. This variety is far more resistant to constant irritation, therefore requiring less reseeding than other varieties. Important target areas for this type of lawn remediation include the Wilson College quad and the courtyard surrounded by Little, Pyne, and Laughlin.

After Thursday and Saturday nights, students on the way home from weekly festivities at Prospect Street tend to destroy vegetation, remove the chain and post barriers around grassy areas, and put liquids into the bushes. When chains are down, students are more likely to stray from paved walkways. The dumped liquids change the pH of the soil, causing further damage to the vegetation.

Pesticides

The sole recommendation made in the 1995 PERC audit regarding pesticides was to seek a substitute for toxic pesticides such as “Roundup,” which is designated by the Environmental Protection Agency as a possible human carcinogen. Though the use of “Roundup” has decreased due to the application of other weed-control measures, it is still used occasionally to discourage weed growth along the border of walkways and vegetated areas. Since reseeding is done so frequently, the sheer number of new grass seeds discourages most weed growth. Improvements to IPM have also decreased the need for pesticide-based weed control.

The IPM system, which brings a more ecological approach to vegetation maintenance, has been modified in two ways since the PERC audit. The first change is the new requirement that no more than 5% of the same plant species be planted in any single area to reduce the risk of pest infestation and the spread of disease. This policy is an application of the observation that as biological and genetic diversity increases in a plant community, resistance

to disease or pest infestation and resilience to environmental change also increase. Even though this system is widely effective at deterring pests, many native plants are still highly vulnerable to exotic pests such as a bacterial leaf scorch, European pine shoot moths, and Asian long-horned beetles. Due to the threat of Dutch elm disease, the two hundred elms on campus must be treated to make them resistant to this deadly disease. At the time of the PERC audit, this was being done with a fungicide called Arbortech. However, the Grounds and Maintenance Department became concerned about the environmental contamination caused by this chemical treatment and switched to a biological treatment wherein a microorganism that specifically targets Dutch elm disease is injected directly into infected trees.

Runoff Control and Paved Surface Reduction

As more of the campus is paved with asphalt and concrete, the volume of runoff during rainstorms and from irrigation increases. As a result of this increase, more pollutants are carried to Lake Carnegie, the recipient water body of the campus's surface runoff. This type of pollution is called nonpoint source pollution, meaning there is no single origin of the contaminant, and is one of the leading causes of surface-water quality impairment in New Jersey and worldwide. Grounds and Maintenance built a new detention basin below the new student parking lot bordering the train tracks and Faculty Road to slow runoff and allow some of the pollutants to settle out before the water flows into the lake. Several large basins have been built around campus and more detention basins are being planned to slow the flow of runoff in other new and existing paved areas.

Efforts have also been made to reduce the paved area in existing parking lots by building more tree islands. In Lot 23 by the new stadium, 154 additional trees were recently planted to cool the area, resulting in the loss of seventy-five parking spaces. In the summer of 2000, new tree islands were planted in the lot below the cogeneration power plant for the same purpose. As these trees mature, they will shade the asphalt and cool the parking lot, simultaneously benefiting the environment by providing habitat for wildlife, removing carbon dioxide from the atmosphere, and reducing the volume of surface runoff by intercepting some rainfall.

Irrigation

Ninety-five percent of plants are watered with hand-held hoses according to need. During the water crisis in 1999, the Grounds and Maintenance Department pumped water from Lake Carnegie for irrigation instead of using valuable drinking water supplies. Three small areas are serviced by automatic irrigation systems that are activated when precipitation is not providing sufficient moisture. Also during the water crisis, the athletic fields' irrigation systems were shut down, allowing the fields to go dormant in order to conserve water.

Composting and Recycling

Grounds and Maintenance has been successful in reducing its emissions of noise pollution. Each fall, the department collects massive amounts of leaves that are shed by trees and makes them into fertilizer or compost. The leaf-collection process used to be carried out with backpack leaf blowers that released

90–110 decibels when in use; ear protection is recommended for noise exceeding 85 decibels. In addition to being extremely loud, it was very time consuming to collect all the leaves with these small, gas-powered blowers. In the past few years, Grounds and Maintenance has begun to switch to larger, diesel-powered leaf blowers that collect leaves faster and release fewer than 85 decibels.

Once collected, these leaves, in addition to tree trimmings and dead branches, are composted at a cost of $5 per ton. Disposing of these materials would cost $12 per ton, so composting saves $7 per ton of leaves. One-third of the soil used around campus is compost from the recycling of the University's own flora. Some of the compost the University produces is sent to local off-campus sites as well. Overall, organic waste recycling has decreased due to the drought periods, which reduce the total amount of biomass added to trees in new growth.

Masonry, metal, and any other construction waste from campus construction projects not controlled by outside contractors is fully recycled. Old concrete and asphalt are ground up and used to make new asphalt or road base materials on and off campus. Recycling of construction waste avoids landfill disposal costs and provides raw materials that will not have to be purchased. The amount of construction and organic wastes vary depending on the number of projects in a year, but regardless of the total amount, Grounds and Maintenance fully recycles all organic waste and masonry and metal waste from construction projects.

Landscape Architect

The University recently hired a landscape architect to coordinate the various landscaping projects on campus. Before this position was created, the architect for each new building would employ a landscape architect for the specific project, which resulted in a lack of coordination between buildings, their surrounding landscapes, and the landscaping for nearby buildings. The University landscape architect will coordinate all future projects with architectural firms to reduce duplicative landscaping, encourage the use of native plants that require less pesticide use and irrigation, and generally help reduce floral maintenance on campus.

ASSESSMENT AND RECOMMENDATIONS

Grounds and Maintenance is one of the few departments on campus that operates with the express goal of reducing the campus's negative environmental effects, and it is doing an exemplary job, though there is room for improvement in certain areas.

Reunions

This annual event inevitably damages the University's grassy areas due to the sheer volume of people and the covering of grass when stages and tents are erected. The new method of diverting water from the grass, shown to be successful in 1999, should be expanded to encompass all sites. Layout of reunion sites should continue to be designed to minimize foot traffic on grassy areas. A sixteenth reunion site was recently added, and yet more sites would allow further alternation between sites used from year to year. In the long term, expanding this idea would facilitate improved grass health in all sites.

Student-Related Impacts

The University should examine the feasibility of further restricting vehicular access to grassy quad areas as a way to minimize the amount of reseeding throughout the year. When students move to and from campus, central drop-off /pick-up sites could be established so that their personal belongings can be carried to a central location, where vehicles pick them up. Campus transportation would have to be expanded to accommodate people during these moves, and perhaps a student agency could also offer services to meet students' changing needs. A large parking lot could be used for this purpose, but it would be challenging to find a suitable, paved central location.

A more viable alternative is to allow vehicles into the quads, but to restrict them from parking on grassy areas. To assist the implementation of this policy, more permanent barriers should be erected in the place of the chain-and-post method currently in use, and tickets should be given to drivers who fail to follow the guidelines. Public Safety officers who currently monitor traffic during check-in and check-out should direct vehicles to park and drive only on paved surfaces. If properly implemented, this alternative would eliminate most traffic on grassy areas and continue to allow the convenience of driving close to dorms so that students' belongings do not have to be carried long distances. Delivery vehicles should be denied access to grassy quads altogether. Many quads are currently protected from vehicular access for most of the year with the exception of check-in and check-out.

Pesticides

Changes in pesticide use since 1995 have reduced their negative environmental impact. Wherever possible, biological pest control, such as that used to combat Dutch elm disease, should be implemented to reduce the use of harmful or polluting chemicals. Manual weed removal, which poses no environmental or human hazards, should be used when possible.

Runoff Control and Paved Surface Reduction

Detention basins and tree islands are important measures to mitigate non-point source pollution from the University and to reduce the detrimental effects of impervious surface areas. Grounds and Maintenance should continue along these lines and perhaps explore other runoff control measures such as constructed wetlands that can remove more pollutants than simple detention basins.

Irrigation

Efforts to reduce the environmental damage from irrigation are in full bloom. The University should continue to plant native species that require less water since they are adapted to the local climate.

Composting and Recycling

Grounds and Maintenance is doing a fine job of recycling material and using the recycled material on campus. The University should expand use of its own compost whenver possible to save on fertilizer costs and reduce the amount of energy expended to transport the materials. Reuse and recycling of construction waste other than metal and masonry should also be investigated periodically to deter-

mine if there are alternatives to sending all other construction waste to landfills.

Landscape Architect

The landscape architect should take an ecosystem approach to enhance the University's green space. Landscaping plans should continue to emphasize native species and vegetation should be minimally pampered to allow it to develop more naturally.

REFERENCES

Office of Grounds and Maintenance: Jim Consolloy

ENV 201 Groundskeeping Report: Peter Boger '01, Jon di Cristina '02

PERC Audit Other Areas of Impact Section: Pesticides: Hans Hull '97

Chapter 6

TRANSPORTATION

At the time of the 1995 audit, an Employee Trip Reduction Plan (ETRP) held enormous promise for improving employee commuter practices. However, a change in state law has since made this plan voluntary, and the ETRP has been dropped. The number of cars on campus, represented by parking spaces, has almost doubled, going from 4,180 in 1995 to 8,115 in 1999. Fuel consumption by the University has gone up by 2,880 gallons during that time, due to a small expansion of the vehicle fleet coupled with an increase in use. Centralizing the management of the vehicle fleet, which is currently managed by individual administrative and academic departments, would improve its efficiency. Implementing parking fees for employees and increasing the cost for students would provide an incentive for both to find other means for commuting to campus.

INTRODUCTION

Princeton University requires a substantial amount of transportation. As a major employer and research and residential institution, its practices, policies, and infrastructure have significant environmental impacts, including pollutant emissions, energy consumption, vehicle congestion, land use, and hazardous waste. By factoring environmental concerns into decisions regarding transportation, Princeton can influence regional policy and become a leader in creative transportation solutions.

At the time of the 1995 PERC Environmental Audit, the Employee Trip Reduction Program (ETRP) promised to significantly improve the practices of University commuters. The program has since been abolished due to changes in state policies. The 1995 audit focused primarily on the ETRP, only briefly mentioning efforts to improve on-campus elements such as the University's vehicle fleet, parking, and intracampus transportation.

This report expands on the 1995 audit, providing an overview of the current state of transportation at Princeton, divided into four categories: Faculty and Staff, Students, Campus Concerns, and University Vehicle Fleet. Suggestions similar to those made in 1995 are included in this chapter, in order to improve student and employee awareness and to centralize control of the University vehicle fleet.

DATA, AND COMPARISONS

Certain areas of transportation were not addressed by the 1995 audit. We have thus attempted to fill these gaps by looking at past records kept by the Business Office, Public Safety, and the Parking Office.

Faculty and Staff

Employee-Owned Cars

Approximately 3,800 cars owned by full-time faculty and staff arrive and park on campus each day. An additional 2,000 part-time employees also commute by car. In 1999, 2,000 temporary vehicle passes were issued, many to University employees.

Employee Trip Reduction Plan

At the time of the 1995 audit, the Employee Trip Reduction Program was in its initial stages, and met with a great deal of enthusiasm and commitment from University employees. The program would have required, under the 1990 Clean Air Act Amendments (CAAA), that all employers meeting certain criteria implement an employee transportation plan to reduce the number of commuters. However, shortly after the release of the audit, the head of the New Jersey Department of Transportation, Frank J. Wilson, announced that these reductions would become voluntary. To comply with the stricter clean air requirements put forth by the CAAA, the state of New Jersey would concentrate on lowering factory and plant (i.e., *non-mobile* source) fossil fuel emissions instead. This announcement was coupled with the designation of September as state "Ridesharing Month."[1]

Upon the repeal of the mandatory reductions, ETRP was discontinued at the University for economic and practical reasons. Without the threat of a fine for failure to comply with emission targets, the University had little incentive to continue the costly reduction process, which included hiring additional employees, conducting educational sessions, and providing alternative transportation. While the ETRP seemed like a very promising means for reducing commuter vehicles and the methods it implemented were creative and compelling, without economic or government enforcement it was completely abandoned over the past five years. At present, twice-monthly seminars are hosted by visiting employees of the Greater Mercer Transportation Management Association (GMTMA) to provide transportation information, but they are generally poorly attended.

Students

Student-Owned Vehicles

The number of student-owned cars in the vicinity of campus is around 2,400, up from 2,000 at the time of the PERC audit. This increase has resulted in the construction of a new lot, #23.

Transportation

Student transportation habits and the lack of awareness of vehicle emission and congestion problems have changed little since the 1995 audit. The Undergraduate Student Government (USG) has taken over the Electronic Ride Board that was used in 1995. This service, which helps students find carpools over the holidays and summer, has increased in popularity as Internet use has gone up over the past five years. Also currently available through the USG website[2] is information on shuttle service to transport students to movie theaters and supermarkets.

TABLE 6.1.

Student travel survey.

	Undergraduate	Graduate
1. Do you have a car on campus?		
Yes	50 (32.3%)	16 (61.5%)
No	105 (67.7%)	10 (38.5%)
2. If yes, how many passengers do you have in your car on an average trip?	1.464	1.2
3. If yes, how many hours do you drive per week during local travel?	1.27	4.6
4. How many hours of long distance travel do you accumulate during the school year?	50.1	75.8
5. Do you travel mainly by:		
Plane?	57	15
Train?	28	0
Car?	70	5
Bus?	3	0

The PERC audit suggested that a survey of student travel be conducted to gain information that would assist in effectively improving transportation. A limited survey of this type was completed in the fall of 1999, polling 155 undergraduate and 26 graduate students on both short- and long-distance travel (see Table 6.1).

Campus Concerns

Intracampus Transportation

Both current forms of intracampus transportation, the campus shuttle and Tiger Tram, were already well established at the time of the 1995 audit. The campus shuttle has maintained a similar route, running a continuous loop through campus (including the Graduate College) seven days a week. Since 1995, it has added an additional forty-five minutes to the end of its schedule, so that it now operates from 5:00 P.M. until 1:30 A.M. Public Safety's Tiger Tram has stuck to its 1995 route and schedule, servicing campus between Lot #16 and Firestone Library (with intermediate stops) from 5:30 A.M. until 7:30 P.M., Monday through Friday, having recently increased their hours of operation. Both of these systems moderate their hours during summers and holidays.

Pedestrians and Bicycling

Walking and bicycling have remained the most popular modes of transportation on campus. The University continues to provide bike racks outside most buildings, as well as bicycle registration and the loan of bike locks (free of charge). Theft continues to deter bicycle use on campus.

The University has continued to make pedestrian traffic easier on the campus by installing additional stoplights and crosswalks on the roads and maintaining walkways throughout campus.

TABLE 6.2.
On-campus parking.

Parking Lot Users	1995	1999
Faculty and staff	2,250	5,800
Graduate students	1,130	1,215
Undergraduate students	800	1,100
Total	4,180	8,115

Mass Transit

Princeton is well connected with many of the major cities of the East Coast corridor and beyond. Few mass transit changes have been made since 1995. New Jersey Transit runs a small train, the "Dinky," onto campus, connecting Princeton to state and regional train lines out of Princeton Junction. From there, N.J. Transit and Amtrak connect to New York, Trenton, Philadelphia, and numerous other destinations.

Suburban Transit operates an express bus to New York City, stopping in front of Nassau Hall. Bus systems also connect Princeton to other metropolitan areas and businesses along Route 1. Several private shuttle companies offer transportation to Newark and John F. Kennedy airports.

Land Use and Parking

As of April 1995, the University parking office administered 4,180 parking spaces in thirty main lots. A large portion of these spaces went to students: 1,130 to graduate students and 800 to undergraduates. The remaining 2,250 spaces were taken by faculty and staff. The number of spaces issued in 1999–2000 was almost double the 1995 number: a total of 8,115 residential and commuter spots (see Table 6.2). An additional 2,000 temporary passes were issued to students, faculty, and staff. University employees continue to occupy the majority of the spaces, occupying 3,800 full-time and 2,000 part-time spots. Undergraduate students account for 1,100 of the cars parked on campus, and graduate students hold 1,215. In addition, there are approximately 300 student-owned vehicles that park on campus during breaks.

Parking fees for students in 1994–95 were $115 for a car and $50 for a motorcycle, with no charge to University employees. Fees have risen to $130 over the past five years. An additional lot, #23, has been constructed to accommodate increases in student-owned vehicles on campus.

University Vehicle Fleet

Procurement

The 1995 audit mentioned the importance of considerations of vehicle fuel efficiency and emissions at the procurement stage. Because purchasing and leasing decisions are made at the departmental level, the audit did not examine the subject further. The process has not changed in the past five years: all vehicles are purchased by individual departments, independent of any central authority. No University policy governs fuel efficiency or emissions, so decisions are based primarily on cost. Environmental standards for the vehicles are only those of the manufacturers.

While the 1995 audit did not contain data on the size of the University vehicle fleet, data ar-

TABLE 6.3.
Size and content of vehicle fleet.

Type of Vehicle	1994/95	1999/00	Change
Cars	65	50	- 15
Cargo vans	152	167	+15
Trucks	39	41	+2
Passenger vans	25	50	+25
Passenger buses	2	0	- 2
Shuttles	4	5	+1
Trailers	25	25	0
Licensed golf carts		3	NA
Unlicensed golf carts		28	NA
Total vehicles	312	338	+26

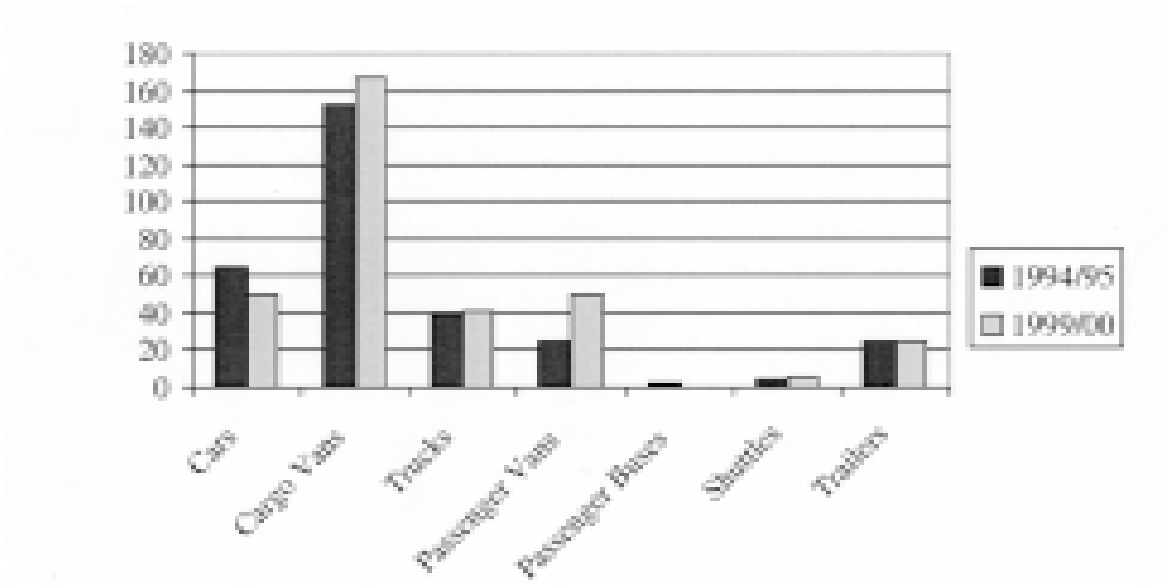

Figure 6.1. Vehicle fleet size and content.

chives currently available show the number and types of vehicles owned by the University in 1994 – 95. These numbers can be compared with current data to get an idea of the rate of change in fleet size and content (see Table 6.3 and Figure 6.1).

The total number of vehicles owned by the campus has increased by 26 vehicles over the past five years, the most substantial addition being 25 additional passenger vans. While the number of cars has decreased and the University no longer owns any passenger buses, the number of all other types of vehicles has grown. A more complete list of Uni-

TABLE 6.4.
Gasoline consumption (in gallons) by University owned vehicles.

Month	1995	1999 - 2000	Change
January	10,409.6	11,059.2	+649.6
February	13,114.7	11,687.1	- 1,427.6
March	14,200.6	10,797.5	- 3,403.1
April	10,615.3	11,198.5	+583.2
May	13,990.7	11,105.9	- 2,884.8
June	10,359.9	10,664.4	+304.5
July	8,942.8	1,0231.4	+1,288.6
August	10,779.2	10,652.3	- 126.9
September	11,801.4	10,406.9	- 1,394.5
October	13,000.9	10,114.6	- 2,886.3
November	5,739.0	10,488.5	+4,749.5
December	3,457.5	10,874.03	+7,389.53
Monthly mean	10,533.47	10,773.36	+239.89
Total gallons	126,401.6	129,280.33	+2,878.73

versity-owned vehicles, including public safety vehicles, tractors, cranes, forklifts, and boats, was not available for 1995. In January 2000, the University owned 485 vehicles, including the latter categories, meaning that 147 vehicles, or ~30% of the fleet, is not represented in the data in Table 6.3 and Figure 6.1. Similar percentages may be assumed for 1995, though actual numbers are unknown.

Vehicle Maintenance

Vehicle maintenance was not addressed in the PERC audit, though it was mentioned as an area of potential environmental importance. Currently, the MacMillan garage is the site of all repair and maintenance of University-owned vehicles. The garage recycles used batteries and tires. Oil and other potentially hazardous materials are disposed of according to applicable regulations. An effort is made to use refurbished auto parts in repairing vehicles; however, quality and cost are the primary deciding factors. No environmental considerations influence garage procedures, so recycling is only implemented when it is economically beneficial.

Most gasoline consumed by University-owned vehicles is purchased from a main campus pump. Occasional additional purchases are made off-campus, for example on longer athletic or outdoor action-type trips with University vehicles. Stored data for gasoline purchases in 1995 were accessed to make a comparison with consumption in the year between April 1999 and March 2000 (see Table 6.4).

Total consumption increased by 2,878.73 gallons, or 2.3%. This number must take into account increases in fuel-efficiency standards in cars manufactured between 1995 and 2000.

ASSESSMENT AND RECOMMENDATIONS

Faculty and Staff

The abolishment of the ETRP has meant a significant decline in what appeared to be one of the most promising areas for improving Princeton's environmental impact. The enthusiasm and improvements of 1995 have been lost with the withdrawal of governmental pressure to reduce the number of commuter cars.

University employees make up the bulk of daily traffic for which the University is responsible, so any reductions in congestion and commuter-related problems should begin with this sector. By returning to some of the measures taken under the ETRP, the University would be able to independently reduce its number of commuter vehicles. Disincentives for driving to work could begin with a parking fee coupled with discounts and preferential parking for carpools. Other incentives to carpool or use other forms of transportation, including meal discounts, special train or bus fares, or shower access for bikers, could have a substantial effect on the volume of daily traffic to the University.[3]

Students: Campus Concerns

The USG Electronic Ride Board is a valuable resource for student ridesharing. The immediate availability of mass transit and shuttles are also useful in reducing the amount of regular student car use. As shown in the survey, most undergraduate-owned cars on campus are used for little other than long-distance travel. Unfortunately, these cars must be accommodated in paved lots that cover large portions of the University campus. Many of the cars are not being used on a regular basis, so a simple measure such as a substantial increase in the parking fee might significantly reduce the number of student-owned cars and eliminate the need to continue expanding the parking facilities. The survey indicates that graduate students use their cars on a more regular basis, but do not appear to carpool regularly. Improved shuttle services between the Graduate College and graduate student housing might help to reduce the number of graduate student commuters. Increasing education and incentives might encourage students to use the various available forms of mass transit for both their short- and long-distance travel needs. The survey indicates that the bulk of travel by students is done via private car, a highly inefficient mode of transportation.

The sample size of the survey included in this audit is sufficiently small that no concrete conclusions may be drawn from it. A more comprehensive poll should be conducted in conjunction with the distribution of parking passes. The survey would both help raise awareness of the implications of automobile use and assist with planning and alterations of transportation services.

University Vehicle Fleet

Environmental concerns do not factor into either procurement or maintenance of University vehicles. Economics governs the decisions made by each department regarding its own vehicles. Both the size of the University vehicle fleet and the amount of gasoline it consumes have increased over the past five years (see Tables 6.2–6.3 and Figure 6.1). Removing the responsibility for vehicle and transportation decisions from the departments

and placing them under a centralized authority would make it much easier to monitor changes and enforce policies.

Under a centralized system, long-term economic benefits associated with higher fuel efficiency and alternative-energy-source vehicles could be assessed and implemented.

REFERENCES

Princeton University Business Office: Kathleen Moore

Princeton University Department of Risk Management: Karen Bauer

Princeton University Department of Public Safety: Chuck Nouvel

Princeton University Parking Office: Connie Hensley

ENV 201 Transportation Report: Phil Belin '00, Lindsay Campbell '02, Beth Lowe '00

PERC Environmental Audit Transportation Chapter: Timothy Larson '96

[1] An online version of the press release regarding "Ridesharing Month" can be found at *http://www.state.nj.us/transportation/framed/press/sept1996/rideshar.htm* .

[2] *http://www.princeton.edu/usg*.

[3] See 1995 PERC audit for a more extensive overview of the content of the ETRP.

Chapter 7

FOOD SERVICES

The large number of food distributors on campus makes this sector difficult to evaluate. Few changes have been made by either the eating clubs or the cash operations on campus, both of which generate large amounts of organic and inorganic waste. The Department of Dining Services (DDS) has improved some policies under the guidance of Stuart Orefice, the new director. The opening of the new Frist Campus Center in Fall 2000 is changing dining patterns on campus. Increasing bulk procurement, recycled and reusable goods, and disposal methods will reduce the amount of waste generated by food services on campus. DDS is the only food distributor on campus over which the University has direct control, so improvements must begin here. If successful, new procedures are likely to spread to the other facilities.

INTRODUCTION

The provision of food to as large and diverse a group as Princeton's student body and faculty will inevitably create a great deal of waste. In all three phases of production: procurement, preparation, and consumption, inorganic and food waste is generated, requiring proper disposal. Both environmental and economic benefits may be obtained by improving the inefficiencies involved in food services.

Many different facilities and organizations are involved in providing food on campus, so a cohesive evaluation of the overall practices and policies is very difficult. DDS is the only University-operated system and the primary food source for undergraduates, serving over 60% of that student body. Eleven privately run eating clubs comprise the major providers for upperclass students at the University.

Until recently, little effort had been made to reduce the waste generated in the process of food production. In 1993, following the arrival of Stuart Orefice, the new director, DDS underwent a reorganization that began to implement improvements in the efficiency of the system. Changes in the procurement and waste-management stages have helped to reduce the ecological impact of Dining Services since the release of the 1995 PERC audit. Successful alterations in DDS policies will provide an example for other food providers on campus. Continuation of improvements in efficiency and the effort to raise awareness among students and employees promise to reduce environmental and fi-

TABLE 7.1.
The Department of Dining Services.

DDS Contracts	1994	1999
Number of students contracted with DDS	2,799	2,854
% student body	62%	62%
Number of upperclass contracts	140	125
% of total contracts	5%	4.4%

nancial costs in this highly improvable sector of the University.

DATA AND COMPARISON

Without a central source of information, it is difficult to gather data on all areas of food services on campus. Much of the data used is qualitative and drawn from the PERC and ENV 201 reports on the subject. Additional information has come from Dining Services. Unfortunately, the eating clubs have been reluctant to comply with efforts to gather information on their procurement and waste policies.

Dining Services

DDS provides the majority of food services on campus. All underclassmen (freshmen and sophomores) are required to contract their meals with DDS, with the option of continuing this contract for their last two years on campus.

The composition of Dining Services has changed little since the release of the 1995 audit (see Table 7.1). The percentage of student contract holders has remained the same, while the percentage of upperclass contract holders has diminished slightly (0.6%). The opening of Frist Campus Center should considerably alter the impact of Dining Services. Incorporated into meal contracts, as well as operating on a cash basis, this new dining facility is likely to cause an increase in the production of waste.

Residential Colleges

DDS manages several types of facilities on campus, the largest of which is the system of residential college dining halls. These dining facilities have undergone few changes since the 1995 audit. The most significant improvement from an ecological standpoint has been in the procurement stage of food production. According to the director of DDS, vendor deliveries have been reduced by 30% over the past five years, though the specific causes of these reductions are unclear. Most likely, it is due to a recent reduction to two dry/frozen vendors. The financial increase associated with the elimination of competitive bidding has been more than compensated for by cost-effective bulk drop-offs from the primary vendor, Sysco. The increase in bulk buying has also reduced the amount of waste generated in the procurement process, lessening waste disposal costs.

DDS has implemented a new computer program, FoodPro, to keep track of food use and leftovers. The software tracks everything that enters and leaves the storeroom, as well as discrepan-

cies in production and consumption amounts. Along with an increase in the number of sous chefs in each kitchen, up from one in 1995 to five, the computer program has helped to reduce the purchases and waste produced by Dining Services.

Though waste has actually gone down, each dining hall still produces about 200 pounds of food waste per day. This figure yields a conservative estimate of 25,000 pounds per month, which is close to half of the total food production. In 1995, at the time of the release of the PERC audit, a pig farmer disposal process had just been implemented. Under this system, all food waste from dining halls and kitchens is collected by the pig farm and boiled at high temperatures. The cooled product is fed to the pigs, and their manure is converted to peat moss. Plastics that are sifted from the manure are purchased by building companies and used to reinforce building material.

The pig farmer program is both environmentally friendly and economically beneficial. Not only does it reduce the amount of waste disposed of in landfills, but it also lowers disposal costs. Over the past five years, the program has been expanded, and waste collection processes have been improved.

No improvements in recycling policy have occurred since the 1995 audit, though Dining Services worker training now includes recycling training. All cardboard, plastic, aluminum and tin cans, plastic containers (numbers 1 and 2), and cooking oil are recycled. Dining utensils are washed and reused, though occasional equipment failure requires the use of disposable serving materials (paper plates, plastic cups, etc.), dramatically, though temporarily, increasing non-food waste.

Other Dining Halls

DDS operates several dining facilities on campus in addition to the residential college dining halls. Contract holders may also dine at these facilities. The graduate college dining hall functions much like those in the residential colleges. The Center for Jewish Life offers kosher meal plan options for both under- and upperclass students. It is the only DDS-operated facility that does not participate in the pig farmer program. The Frist Campus Center is probably the most popular undergraduate residential college alternative, offering late-meal and cash options. All of these dining halls operate much like the residential college facilities in terms of procurement and waste management. No specific information on these food services was provided in the 1995 audit, nor did Dining Services have any available current data.

Cash Operations

In addition to the facilities covered under meal contracts, DDS runs several cash operations on campus. Chancellor Green Café is frequented mainly by students and provides only disposable dining utensils, creating a good deal of nonrecyclable waste as well as excessive economic expenditure. The New South and Woodrow Wilson School cafés appear similarly inefficient, though no specific data were available for any of these sites.

Upperclass Options

Eating Clubs

In addition to the choice of extending PUDS meal contracts for an additional two years, upperclass students have several dining options at Princeton, the most popular of which are the eating clubs. Long a University institution, the eleven clubs located along Prospect Avenue are the primary dining facilities for juniors and seniors, besides serving

as the social hub of the school. Each club is a private organization not affiliated with DDS or the University administration, making it very difficult evaluate or enforce club policies. Most eating clubs have recycling programs that have been in place since before the 1995 audit. Economic concerns have stagnated most efforts to improve the environmental impacts of the clubs.

The largest of these impacts is of special social importance and of particular ecological concern. Plastic cups serve as the only beverage containers at the clubs during the weekend. They are not recycled, and are often disposed of in inappropriate locations. Campus Club, one of the less-frequented clubs on campus, estimates the use of 4,000 cups per week at an expenditure of $90 weekly. So far, all attempts to establish a "Bring Your Own Mug" policy have enjoyed only limited success.

Food Co-ops

As an alternative to the eating clubs, upperclass students may join one of the two dining co-operatives, Brown or 2 Dickinson. The ecological impact of these facilities is minimized due to the serving of primarily vegetarian and vegan meals, and due to their composting and recycling programs.

Independents

Some upperclass students opt not to join either an eating club or a food co-op, choosing instead to remain independent and prepare their own food. The University cannot be responsible for the impact of these students, though their habits may be influenced by the University's overall efforts to increase awareness.

ASSESSMENT AND RECOMMENDATIONS.

Dining Services has made a considerable effort since the release of the 1995 audit to increase efficiency and decrease waste. Though the motivations have been primarily financial, the result has been a number of dramatic ecological improvements, such as the expansion of the pig farmer program and the switch to bulk procurement. The correlation between environmental and economic concerns should help encourage increases in efficiency in all of the dining facilities on campus.

Though progress has been made over the past five years, the efficiency of food services at Princeton can still be increased significantly. Continued efforts on the part of Dining Services will help further the recent decrease in waste production. Data on the policies and practices of other dining facilities on campus should be collected and examined to determine areas to be targeted for improvement. Providing creative solutions for waste reduction and management that ally economic and environmental concerns will encourage facilities to adopt more efficient policies. The successful pig farmer program is a perfect example of the implementation of such an alternative.

Most of the suggestions put forth by the 1995 PERC audit have been implemented over the intervening time period, including the reduction in vendor purchases and the expansion of the pig farmer program. Recycling of non-food waste is the one major area in which little progress has been made.

Individual awareness of the ecological and economic costs of inefficiencies in the production and consumption of food can add up to a significant impact. If the students themselves would waste less food, the overall efficiency of the dining facilities would be substantially increased. Waste disposal

costs, purchasing quantities, and ecological impact could be cut with only minor alterations in the behavior of each individual. Administrators and eating club officers must be made aware of the environmental and economic potentials of food services at the University. As private organizations, the eating clubs would be particularly open to such suggestions; lack of awareness is the primary hindrance to change.

The many components of food services at the University require the collection and evaluation of much more data and policy information before any clear understanding of the environmental impacts of this sector can be reached. Such an understanding is important for the proposal of feasible and efficient changes.

REFERENCES

Department of Dining Services: Stuart Orefice, Director

ENV 201 Food Services Report: Tom Quirk '00, Annika Walters '02

PERC Audit Food Services Chapter: Eckhart Richter '98

Chapter 8

SOLID WASTE AND RECYCLING

Significant improvements in the recycling program since 1995 have been of great financial benefit to the University and have decreased its environmental impact. Though the structural recommendations of the PERC audit were not accepted by the University, the broad recommendation of improving awareness of the recycling program was observed to some degree. Continued efforts to increase student and faculty involvement in recycling on campus and to encourage the use of reusable materials would substantially increase the savings generated from this more ecologically sound method of disposal. The janitorial staff should also observe stricter enforcement of recycling policies. Savings in landfill avoidance costs would be enhanced by appointing a recycling coordinator to expand and monitor the program.

INTRODUCTION

The University's recycling rate has increased by 13% since 1995 due to improvements in recycling technology and a new food waste recycling program. According to the New Jersey Statewide Mandatory Recycling and Source Separation Act passed in 1987 and other state mandates, the University must recycle 60% of its municipal solid waste by weight — a requirement that was met and exceeded in 1995 and is still in effect. The Facilities department, through both the Grounds and Maintenance and Building Services departments, handles recycling efforts on campus. Significant decreases in both municipal solid waste sent to landfills and medical waste have occurred since the 1995 audit despite campus growth. In 1995, only 25% of the waste processed by Building Services was recycled, but this figure has improved to 42% over the past five years. These improvements in recycling were facilitated by technological improvements in recycling capabilities and a new food waste recycling program.

Since FY97/98, the University has not been paid for recycling commingled paper, aluminum, or glass, though it is not charged to dispose of these items, either. Though the University generates revenue from solid waste solely through the sale of scrap metal, tremendous savings are made possible by recycling materials. These savings are represented by Cost Avoidance Fees that encompass the costs incurred by recycling and processing waste,

TABLE 8.1.

Comparison of waste and recycled material tonnages from FY94/95 and FY98/99.

Type of Waste	FY94/95	FY98/99	Difference
Municipal solid waste	3176.35	2,643.77	- 532.58
Recycled food waste	132.50	514.50	+382.00
Medical waste	57.13	24.00	- 33.13
Building services recycled material	1,188.93	1,432.67	+243.74
Commingled paper	900.19	1,087.04	+186.85
Cans/bottles	241.18	286.80	+45.62
Scrap metal	47.56	58.83	+11.27

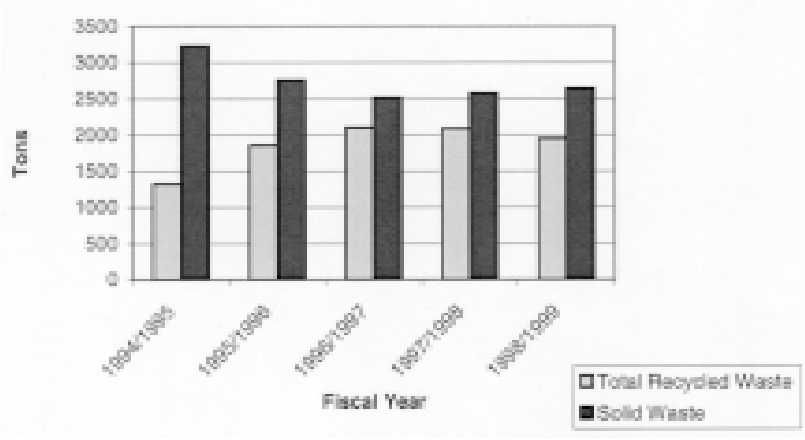

Figure 8.1. Changes in solid waste and total recycled waste since FY95.

thereby avoiding landfills. Technically, the University saves approximately $180,000 more now than it did in 1995 through landfill avoidance.

DATA AND COMPARISONS

Data for this chapter were compiled from the Fall 1999 ENV 201 Recycling and Paper Use report and the 1995 PERC audit's Solid Waste chapter, as well as from interviews with directors and staff of the Office of Building Services.

Grounds and Maintenance

Grounds and Maintenance is the department responsible for the disposal of organic waste (leaves, trees, branches) and some construction waste (stone, asphalt, masonry, and scrap metal). Other construction waste, such as glass and wood, is not reused or recycled, but sent to landfills. Currently and at the time of the 1995 audit, all organic waste and most construction waste was recycled, accounting for 87% of the total recycled materials in 1995 due to sheer weight. The fact that 100% of these materials are recycled may be misleading be-

TABLE 8.2.

Comparison of recycling rates from FY94/95 and FY98/99.

Recycled Material	FY94/95	FY98/99	Difference
Building Services recycled material[a]	27.24%	35.15%	+7.91%
Commingled paper	20.62%	26.67%	+6.05%
Cans/bottles	5.52%	7.04%	+1.52%
Scrap metal	1.09%	1.44%	+0.35%
Recycled food waste[b]	4.00%	16.29%	+12.29%
Total recycled material including food waste[c]	29.38%	42.41%	+13.03%

[a] Building Services recycled material recycling rate = tons recycled / (tons municipal solid waste + tons Building Services recycled material.

[b] Food waste recycling rate = tons food waste recycled / (tons municipal solid waste + tons food waste).

[c] Total recycling rate, including food waste = total tons recycled material / (tons municipal solid waste + tons Building Services recycled material + tons food waste).

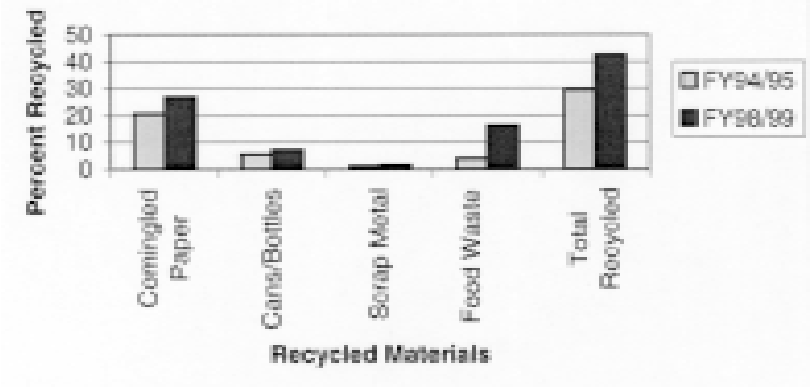

Figure 8.2. Comparison of recycling rates from FY94/95 to FY 98/99.

cause it does not account for the waste produced in large construction projects. The materials used in major construction and renovation are disposed of by individual contractors and therefore are not monitored by the University, though it is expected that their disposal be carried out in a legal manner. Excluding organic waste and construction materials handled by Grounds and Maintenance, 25% of the University's materials are diverted from landfills.

Building Services

Commingled Paper, Cans and Bottles, and Scrap Metal

Building Services collects all of the waste accumulated during daily operations from all campus buildings. Table 8.1 shows the increase in tons of material recycled since 1995, much of which is due to improved recycling capabilities.

All paper products, including newsprint, maga-

[1] HDPE = high density polyethylene. HDPE numbers are used to sort plastics for recycling.

zines, box board, cardboard, envelopes, and paper bags, are recycled. In 1995, Building Services did not recycle magazines or envelopes with clear windows, but technological improvements have enabled them to include these materials and an impressive 95% of all paper products that come to the University. Glass, aluminum, bimetal, and plastic cans and bottles are recycled as well. Plastic containers must be HDPE 1 or 2 plastic[1] and include old one-to-five-gallon chemical cleaning containers. Since 1995, they have been able to add laboratory solvent bottles (alcohol, methanol, and propanol) to their recycled materials list as long as they are triple rinsed and aired out. The addition of these solvent bottles alone, which were previously disposed of as medical waste or regular trash, have allegedly — according to Al King of Building Services — increased commingled recycling by 10%, though the data show about a 6% increase. Batteries of all kinds (i.e., alkaline, mercury, lithium, lead, ni-cad) are sent to a recycling center in Philadelphia. Fluorescent lightbulbs are also recycled, and over 50 linear feet of the mercury-containing tubes have been recycled to date. Finally, wooden pallets upon which large deliveries are received are recycled if they are in good condition. Otherwise, the pallets are sent to a company that either refurbishes them or sends them to a trash incinerator for fuel.

The University is no longer paid for commingled paper or cans/bottles, but is able to dispose of them free of charge and avoid landfill costs. Scrap metal is sold for $2.20 per ton, but since the total tonnage is small the revenue gained is not highly significant.

Municipal Solid Waste

The total amount of municipal solid waste (MSW) sent to the Mercer County Improvement Authority has decreased sizably since the 1995 audit. This change is due to the increase in recycled materials, including food waste and commingled paper. Landfill costs were cut from $117.81 per ton to $98.25 per ton beginning in FY98/99, which does not seem to have greatly increased solid waste disposal in landfills. Though the amount of MSW has grown slightly since reaching a five-year low of about 2,500 tons in FY96/97, the overall trend has been a great decrease since 1995. This drop in solid waste production saved the University approximately $115,000 in FY98/99.

Food Waste

In February 1995 the University started a program with a local company, Neil McIntyre: Recyclers of Food Waste, that uses the University's sterilized food waste from Dining Services to feed pigs instead of sending it to a landfill. There is a $55 per ton pickup charge for the food waste, so this disposal program saves the University just under $40 per ton on disposal costs by diverting the waste from landfills. Beginning with this program, food waste was separated from municipal solid waste and boosted the University's total recycled material tonnage by over 7%. In FY98/99, the total annual savings in disposal costs from this program was over $30,000. Since its inception and taking into account the recent reduction in landfill disposal costs, food waste recycling has yielded $126,318.88 in savings from landfill avoidance.

Medical Waste

All medical waste is sent to Sanford Motors, Inc. for disposal. During FY96/97, Environmental Health and Safety Regulations of the Environmental Protection Agency changed the definition of medical waste, allowing more of it to be diverted into regular trash. This change caused an increase

in the total tonnage of municipal solid waste and accounts for most of the approximate 50% reduction in medical waste tonnage since 1995. Since medical waste costs $520 per ton to dispose, this reduction saved the University $11,621.40 in disposal costs in FY96/97.

Student Involvement

A major weakness of the recycling program cited in the 1995 PERC audit was low student involvement, especially of upperclassmen, which hampers the success of the recycling program. Two of the specific recommendations of the 1995 PERC audit, promoting year-round education on recycling issues and establishing a contact number for recycling information, have been addressed to some degree. According to Jane Hulik, the director of the recycling program, Building Services has been attempting to foster greater student involvement in the program using newspaper ads, distributing flyers, and issuing informational booklets about recycling. Much of this publicity is concentrated in the beginning of the academic year, but it should be continued throughout to remind students, faculty, and staff regularly about recycling. Another recommendation is to explore the feasibility of recycling HDPE plastics from 3 to 6. Many commonly used products, such as yogurt containers, must be discarded because only HDPE 1 and 2 plastics are currently recycled. Furthermore, the eating clubs use HDPE 6 cups, generating large amounts of cups on a weekly basis that are simply discarded. The sheer volume of this source of waste warrants an investigation into recycling operations that could accommodate these materials.

Janitorial Staff

Building Services has also trained janitorial staff to monitor the program more closely, an effort that might have contributed to the increased recycling rates. Janitors have the right to deliver warning notices to students when there are nonrecyclable materials in the recycling bins. After three warnings, a $50 fine can be assessed to deter violations. This tool is an important yet rarely used mechanism for recycling enforcement. Another recommendation that has not been addressed is to teach students how they can ease the janitors' workload by sorting their waste properly.

Administrative Recycling Coordination

The other recommendations from 1995 call for the creation of new structures to regulate campus recycling. The first is to create a University president-appointed committee on recycling that would bring together students, faculty, and staff, including representatives from Housing, Building Services, Dining Services, Undergraduate Student Government, and students from each of the residential colleges and upperclass and independent housing. The committee would meet periodically to discuss student complaints, initiate improvements, and publicize the program and its importance through an annually distributed brochure. This committee has not been formed since 1995, and there are no plans to form one in the near future.

The other structural recommendation was to hire a separate recycling coordinator to chair the recycling program. The current recycling coordinator, Jane Hulik, requested that this new position be founded, since she has other duties as well, but the University refused. Hulik feels that more revenue needs to be generated by the program before the position can be funded. The savings currently generated by the program, on the order of $50,000, could at least partially pay for this position; further improvements to the program made by this coordinator may well fully fund the position. Many other

schools, including Rutgers, Dartmouth, and Georgetown, employ recycling coordinators who play essential roles in their programs.

ASSESSMENT AND RECOMMENDATIONS

Clearly, recycling has improved remarkably since the 1995 PERC audit, though further improvements should be made to generate significant savings. A large increase in commingled recycling was facilitated by improved paper-recycling technology and the inclusion of old solvent bottles in recycled materials. Though part of this increase could be due to increased student involvement, a portion of it is the result of increased recycling capabilities. Several of the many broad recommendations of the 1995 PERC audit have been addressed, though it is not clear if the changes were specifically motivated by those recommendations.

Grounds and Maintenance

Overall, this department is doing a good job of recycling the materials that are easily recyclable. However, a great deal of construction waste that could be reused or recycled is disposed of in landfills. One example is the use of waste glass in a material called "glassphalt," used in paving roads. It is recommended that options such as this be investigated and that they be adopted if the cost is comparable to landfill disposal methods. A recycling coordinator would encourage the development of innovative waste-disposal methods.

Building Services

Student Involvement

Paper-use reduction campaigns should be held throughout the year to constantly remind students to conserve. Expanded efforts should be made close to Dean's Date and during finals periods, when paper use peaks. Signs that encourage students to print papers double-sided should continue to be posted. Notices should be sent to professors encouraging them to accept double-sided papers so that students will be more motivated to cut down on paper use. Professors could include a note in their syllabi addressing this issue and encouraging double-sided printing. We recommend that an overview of paper conservation be incorporated into freshman orientation, perhaps as part of a pamphlet on "How to be 'Green' at Princeton."

Janitorial Staff

A meeting with janitorial staff and students to briefly discuss recycling policies and the students' part in making the program successful could help increase recycling participation. The warning notices and fines should be used more widely because they give students a strong financial incentive to cooperate with recycling efforts.

The recommendation from 1995 that twine be distributed to implement newspaper recycling has been made unnecessary due to the inclusion of newspapers in paper recycling. Spelman recycling has been improved so that each suite receives paper and bottle/can recycling receptacles, though students are responsible for carrying the materials to the dumpster. In other dorms, students are not responsible for emptying their trash and recycling bins.

Administrative Recycling Coordination

The duties outlined for a president-appointed committee on recycling composed of students, faculty, and staff should be implemented through some sort of program, though a recycling coordinator alone may be a more practical approach to improving recycling on campus. The position of recycling coordinator should be reconsidered, since such a person could generate more savings by improving the efficiency of the existing program and seeking out new opportunities to expand its capacity.

REFERENCES

Office of Building Services: George Frierson, Jane Hulik, William Traubel, Al King

ENV 201 Recycling and Paper Use Report: Andre Lamartin Montes '02, Pat J. Shamberger '02, Margit C. Smulovitz '03

1995 PERC Audit Solid Waste Chapter: Mark Higgins '95, Naomi Hayashi '97, Ed Gung '97

Chapter 9

TOXIC AND RADIOACTIVE WASTE

This chapter includes data on metals, biological waste, chemical waste, and radioactive waste. Disposal quantities and costs have gone down in all four areas since the 1995 audit, due primarily to the efforts of the Environmental Health and Safety Office. External government regulations and the high cost of disposal force the University to deal responsibly with its toxic and radioactive wastes. Most of the policies in this sector will continue to be decided externally, so it is up to the on-campus producers of these wastes to ensure that proper records are kept and standards followed in accordance with government and University regulations.

INTRODUCTION

Toxic and radioactive wastes introduce dangerous substances into the environment. If improper disposal occurs, the ecological, economic, and health consequences can be enormous. As a large-quantity producer of these types of wastes, Princeton University must take responsibility in minimizing the amount of waste generated and guaranteeing its safe disposal.

Since the release of the PERC Environmental Audit in 1995, the University has made substantial strides toward improving its toxic and radioactive waste policies. Both the quantity and the cost of disposal have dropped dramatically, well over 50 percent. Improvements in the education of the individuals handling dangerous substances have helped to insure that proper disposal techniques are followed. Government safety inspections have found no violations in recent years, calling Princeton a model facility in management and handling.

Most of the improvements have resulted from the efforts of the Environmental Health and Safety Office. This department carefully monitors practices within the University, encouraging and suggesting assiduous efficiency and safety measures. Financial and governmental pressures serve to reduce the production of both toxic and radioactive waste. Improvements in monitoring techniques and continuing education will help the University continue to minimize waste and costs even as research facilities expand.

TABLE 9.1.
Comparison of types of waste disposal.

Types of Waste	Pre-1995	1999	Changes
Metals	Lead >.7 mg/L	Lead >.5 mg/L	>.2 mg/L
Biological waste	70 tons	22 tons	- 48 tons
	$39,000	$12,000	- $27,000
Chemical waste	51,046 lbs	40,794 lbs	- 10,252 lbs
	$915,850	$65,000	- $130,850
Radioactive waste	Five 55-gallon drum	One 55-gallon drum	Minus four 55-gallon drums

DATA AND COMPARISON

Both the 1995 PERC audit and the ENV 201 report on toxic and radioactive waste provided detailed and complete information, requiring only minor supplementation from the Environmental Health and Safety Office.

Significant improvements have been made in reducing toxic and radioactive waste, incuding metal, biological, radioactive, and chemical waste. The most economically beneficial reduction was in chemical waste disposal, where costs fell from $195,850 at the release of the PERC audit to $65,000 in 1999, a decrease of $130,850, or 67 percent (see Table 9.1).

Metals

The University holds a permit with the Stony Brook Regional Sewer Authority (SBRSA) for the disposal of waste water. Upper limits on the content per liter are placed on twenty-one different pollutants. Lead and silver were the only substances to be found in consistent violation of these regulations in 1995. Over the past five years, the monitoring of silver content has ceased.

Lead

The violations of the 0.5 mg/L limit on lead content in waste water have been successfully eliminated over the past five years. Levels have dropped an average of over 0.2 mg/L, making the University compliant with permit regulations. The reduction was due primarily to improvements of department practices mandated by regular memos sent out by the Engineering Quadrangle's environmental compliance manager. Maintaining compliance allows the University to avoid any fines resulting from permit violations.

Biological Waste

Biological waste includes any solid waste generated from the diagnosis, treatment, or immunization of human beings or animals, and from related research or testing of biologicals. Cultures and stocks of in-

fectious agents, pathological waste, human blood and by-products, sharp implements, contaminated animal waste, and isolation waste from patients with communicable diseases are all considered to be biological or medical waste.[1] The chemistry, molecular biology, and psychology departments and the McCosh Health Center generate most of the biological waste on campus. Regular inspection by the New Jersey Department of Environmental Protection (NJ DEP) and Department of Health determine the compliance of disposal procedures with state and federal regulations.

The 68% reduction in biological waste over the past five years, which has resulted in a spending decrease of $27,000 per year, has not been the result of any actual changes in the production of waste. Instead, the University reclassified several items in this category, such as beakers and test tubes, and it was able to dispose of them according to procedures for ordinary waste. Disposal costs for biological waste are covered by the University, rather than the departments themselves, separating financial responsibility and waste generation. Prior to 1995, this practice resulted in the disposal of all lab waste as biological waste. Improvements in the extraction of nonmedical/noninfectious waste from the contaminated materials have contributed to the reduction in disposal costs, even as the total amount of generated waste remained constant.

Hazardous Waste

Hazardous waste consists of materials that can be classified as corrosive, reactive, or highly toxic.[2] Facilities and the science, engineering, and visual arts departments are the primary on-campus hazardous waste producers. At the time of the 1995 audit, this sector fell under the management of Occupational Health and Safety. In 1997, it changed its name to Environmental Health and Safety, but remained otherwise the same. Two of the four production sites at the University are classified as large-quantity generators; all four have monthly pickups that deliver the waste to licensed disposal facilities off-campus.

The record-keeping procedure for the purchasing and disposal of hazardous waste has not been improved much over the past five years. Disposal records now include the generation site of the waste, which can be used to identify the largest producers. All records are regularly submitted to the NJ DEP and the EPA for evaluation. No violations of state or federal hazardous waste regulations were found during 1999. In fact, NJ DEP was considering using Princeton as a model facility in management and handling.

Disposal costs had begun to drop at the time of the release of the PERC audit, due to increasing use of more efficient packaging that took up approximately a quarter of the space of the previous system and cost about 60% less. In the past five years, the quantity of hazardous waste generated by the University has fallen by over 50 percent (see Table 9.1). The decrease in quantity is due in part to the reclassification of mercury and oils as universal wastes. Mercury waste is now sold to a recycler, Bethlehem Apparatus.

The most drastic cutbacks in hazardous waste production have been the result of the efforts of the Environmental Health and Safety Office (EHS), which has aggressively pursued improvements in waste policies. All departments are encouraged to reduce chemical use, one method being an examination of student lab manuals for potential areas for minimization. The clear classification of hazardous

and nonhazardous waste, available on-line and in other easily accessible locations, has helped to eliminate the disposal of nonhazardous items as hazardous materials. EHS has also enforced increases in student awareness, requiring that all juniors taking core laboratory courses in Molecular Biology, Chemistry, and Chemical Engineering attend a chemical safety and disposal class. All departments in which hazardous materials are handled encourage students to attend a lab safety course that covers chemical disposal.

A surplus chemical exchange program is under investigation, though several difficulties have kept a trial run from taking place. Issues of transportation and chemical purity have kept the program from being implemented thus far.

Radioactive Waste

The 1995 PERC audit outlined the significant improvements, including a 95% radioactive waste reduction, which had occurred since the 1980s. Over the past five years, the amount of radioactive waste has continued to go down, reduced by 80% from the 1995 figure (see Table 9.1). The Molecular Biology Department continues to be the primary generator of radioactive waste. The national Nuclear Regulatory Commission and the NJ DEP monitor the University, supervising compliance with the strict and detailed handling, packaging, labeling, and disposal procedures.

The disposal of radioactive waste incurs a cost that must be covered by each department, unlike toxic waste disposal, which is covered by the University. This procedure provides financial incentive for each department to minimize its production of radioactive waste, which is regulated by the government.

A new guide, the *Radiation Safety Manual*, has replaced the old Radiation *Safety Guide* in a thorough, easily referenced format. Radiation safety education and training have become even more extensive than they were five years ago. Instead of attending a three-hour training session, those using radioactive materials are required to participate in an online instructive module. Upon the module's completion, the person takes a test and submits it directly to EHS. After passing the test, the person proceeds to a training class.

Another substantial impact in the reduction of radioactive waste has been the expansion of the decayed-in-storage (DIS) program. The maximum half-life of wastes that may be included has been increased from 65 to 90 days, increasing the number of solids that can be disposed of as biological waste after being stored until they are no longer detectably radioactive. The Barnwell, South Carolina, disposal site was closed to out-of-state waste shortly before the release of the 1995 audit. It has since been reopened for New Jersey customers.

ASSESSMENT AND RECOMMENDATIONS

The toxic and radioactive waste sector at the University has become much more efficient since the release of the 1995 PERC audit. External governmental regulations combined with high disposal costs are the primary influences on University practices involving waste disposal. The Environmental Health and Safety Office at Princeton has been very successful in minimizing the amount of waste generated by the University. Due to the dramatic reductions in both cost and quantity over recent

years, the primary concern for toxic and radioactive waste now lies in its proper disposal. The substances being handled by laboratories are very dangerous if they are incorrectly disposed. The potential harm to both the environment and humans must be made clear to all those who work with the chemicals. Education in this area must continue to be updated and improved.

1 Defined by New Jersey State Administrative Code 7:26-3A.69a.

2 N.J.A.C. 7:26-8.13 through 8.20.

REFERENCES

Department of Facilities, Engineering: Robert Ortega

University Industrial Hygienist: Robin Izzo

University Health Physicist: Susan Dupre

ENV 201 Toxic and Radioactive Waste Report: Robin Liu ’00, Melissa Waage ’01

PERC Audit Toxic Substances Chapter: Chris Larsen ’95, Laura Felten, Amy Gladfelter ’96, Saumyen Guha

Chapter 10

ACADEMIC OPPORTUNITIES

The recommendations in the 1995 audit have been addressed well over the past few years: diversifiying the Environmental Studies Program (ENV) course offerings, improving the core courses, and advertising job and funding opportunities to students. An array of cross-listed courses has expanded the diversity of ENV course offerings, representing collaborations between ENV and the departments of Economics, Geosciences, History, Religion, Civil and Environmental Engineering (CEE), and the Woodrow Wilson School (WWS). Improvements to the Environmental Studies core courses seem to have attracted more students, and enrollment has begun to rebound from a downward trend since 1991. More extensive advertising of environmental job and research opportunities and of the Environmental Studies Program in general would encourage more students to enroll in the courses and in the certificate program. Further improvements should be made to the core courses, ENV 201 and 202, through the close cooperation of PEI faculty and by careful evaluation of student preferences as expressed in course evaluations.

INTRODUCTION

Students may pursue their interests in environmental issues through several avenues. The Princeton Environmental Institute's (PEI) Environmental Studies Program (ENV), founded in 1991, is a multidisciplinary forum for the study of scientific, political, humanistic, and technological aspects of environmental problems. Undergraduates may pursue a certificate in ENV and incorporate environmental topics into their junior and senior independent work. The courses offered through this program and in conjunction with other departments are a major source of environmental education opportunities. Several freshman seminars offered on environmental subjects also enable students to pursue their environmental interests, including Sustainable Development and the Environment (FRS 122) and Energy in the World Around Us (FRS 101). Many departments throughout the University including Ecology and Evolutionary Biology, the Woodrow Wilson School, Geosciences, and Civil and Environmental Engineering offer courses that emphasize environmental issues.

TABLE 10.1.
Environmental Studies certificates awarded in 1994 and 2000 by department.

Department	1994	2000	Difference
Humanities	1	1	0
Social Sciences	7	4	- 3
Natural Sciences	9	6	- 3
Engineering	10	5	- 5
Total	27	16	- 11

DATA AND COMPARISONS

The data for this chapter were compiled from the 1995 PERC audit's Academic Opportunities chapter and interviews with the director and staff of PEI.

Recommendations from the PERC audit were to (1) improve the currently offered courses, particularly the problem sets and exams; (2) add new courses with an environmental component, including ENV 401 and 411, which had not been offered; (3) make coursework practical by introducing case studies related to Princeton's environmental situation in relevant courses; (4) provide incentives for conducting environmental research through the recognition of contributing professors; and (5) improve the availability of information on career opportunities. The first three recommendations have been actively addressed, and two new environmental job publications have been added to provide information for students. The fourth recommendation seems not to have been addressed as actively.

The Program in Environmental Studies (ENV)

ENV offers students the opportunity to study various perspectives on environmental problems. The certificate program is available to students from any discipline, requiring the completion of the two core courses, three laboratory courses (one from the physical sciences, one from the life sciences, and another one), and three cognate courses, each from a different division. Seniors must participate in a senior thesis colloquium during their senior year. Junior and senior independent work involves an environmental topic that must be approved by the director of the program and the undergraduate representative of the student's department of concentration. Because the program is still a certificate program as opposed to a full concentration keeps it available to students from all departments.

Course Offerings

ENV sponsors two core courses, ENV 201 and 202, that examine a broad range of environmental issues and their anthropogenic causes. Professor Michael Celia (CEE), ENV director, teaches ENV 201: Fundamentals of Environmental Studies: Population, Land Use, Water, and Energy. ENV 202: Fundamentals of Environmental Studies: Climate, Toxics, Air Pollution, and Biodiversity is taught by Professor Bess Ward in the spring. Both now present the option of a laboratory section. Some

major complaints about these courses in the past were taken into account and the courses have been restructured. The Topics Course, ENV411, which was never offered, has been replaced by ENV 305 and 306. These courses will be offered with different topics each year; in 1999-2000, ENV 305 was called Writing About Nature and ENV 306 was called Environmental Law and Policy. ENV 401: Environmental Policy Workshop has been offered during alternating fall semesters by Professor Burt Singer (WWS).

The 1995 audit had suggested that the Environmental Studies Certificate Program expand its course offerings to include more practical applications of coursework, specifically addressing campus environmental concerns and important environmental issues across the globe. In Fall 1999, students in ENV 201 were assigned to update various sections of the PERC audit, and these reports have served as the basis for many parts of the current audit. ENV 306 has also addressed local environmental concerns.

Seven courses offered in conjunction with other departments have helped expand the selection of ENV courses as recommended in the PERC audit. Four cross-listed courses with the Geosciences Department are currently being offered. GEO 524/ ENV 524: Environmental Issues Seminar, taught by Professor François Morel, examines a new topic each semester chosen from various current environmental science problems. Professor Gregory Van Der Vink teaches two courses, GEO 399/ENV 399 and GEO 299/ENV 299. The first of these courses, Environmental Decision-Making, focuses on the use of scientific arguments combined with engineering, economic, political, and social considerations to build environmental policies. The latter course, Setting the New Environmental Agenda, deals with the recent shift in perspective from environmental preservation to the more active role of stewardship. Professor Michael Bender teaches GEO 322/ENV 444: Biogeochemical Cycles and Global Change, which examines the natural biogeochemical cycles of carbon, nitrogen, and other elements, human impacts on these cycles, and climate implications of these impacts.

Two cross-listed courses are being offered with the Civil and Environmental Engineering Department, both taught by Professor Ignacio Rodriguez-Iturbe. CEE 587/ENV 587: Ecohydrology deals with attempts to describe the hydrological mechanisms underlying ecological observations with emphasis on soil-moisture dynamics. CEE 368/ENV 368: Fractal Beauty of Landscapes introduces the basics of fractal geometry and its applications in describing natural forms, like branching river basin patterns.

The Economics, Religion, and History departments are also offering joint courses with ENV currently. Professor David Bradford teaches ECO 319/ ENV 319: Environmental Economics, which introduces uses of economics in thinking about and dealing with environmental issues, particularly incorporating externalities into the economic system. REL 262/ENV 262: Religion, Ecology, and the Environment was offered for the first time in Spring 2001, taught by Professor Bethel Eddy. Another new course for Spring 2001, HIS 313/ENV 313: World Environmental History, was taught by Professors Andrew Isenberg and Emmanuel Kreike.

A wide variety of internships, research funding possibilities, and other academic opportunities are posted on the bulletin board in the basement of Guyot Hall. Two subscriptions provide up-to-date information about environmental career opportunities and conservation jobs, *Environmental*

TABLE 10.2.

Comparison of enrollment in the Environmental Studies core courses in 1994/95 and 2000/01.

Course	1994/95	2000/01	Difference
ENV 301/ENV 201	68	63	-5
ENV 302/ENV202	87	60	-27
Total	155	123	-32

(Note: ENV 301 and 302 were renumbered for the 1995-96 academic year to ENV 201 and 202.)

Career Opportunities (bimonthly) and *EarthWork* (monthly). PEI continues to sponsor three competitive senior research funds that supply financial support for travel, research, and supplies. Two of the funds, the Richard B. Scudder '35 Independent Research Fund and the Edmund Hayes Sr. '18 Fund, support research in environmental science or policy. The Cleveland Dodge Senior Thesis Research Fund in Population and Environment supports research that focuses on the intersection of human population and environmental science and policy.

Student Participation

Slightly more than two hundred students were enrolled in the two core courses when they were first offered in 1991. This number has recently rebounded somewhat from a previous steady decline since then. At the time of the PERC audit in 1995, enrollment was still relatively high, but as Table 10.2 shows, enrollment has continued to decline. The courses' diminishing popularity appears to be due to their disorganization and highly demanding work load. Table 10.1 shows that the number of Environmental Studies Certificates has declined as well, but a higher percentage of the number of students enrolled in the core courses are receiving certificates. Development of new laboratories for ENV 201 and 202 in Spring and Fall 2000 has already served to increase enrollments in those courses.

ASSESSMENT AND RECOMMENDATIONS

The recommendations from the 1995 PERC audit have been relatively well addressed though room for improvement remains. The core courses may require further fine-tuning to attract more students and dispel uncertainties about their quality. Diverse course offerings should continue to be expanded as they have been over the past years. Job and funding opportunities should be further publicized to encourage students to become involved in environmental studies.

To ensure that environmental coursework retains the recent practical additions, students should be assigned to update sections of the environmental audit as a regular element of the core courses. A system in which the ENV course forms the basic foundation of the audits to be compiled by other students is an ideal way to ensure that audits are performed regularly and that they involve many students. The chapters of the audit should correspond directly to student reports so that the reports are of the utmost utility.

The core group of faculty members working to improve the Environmental Studies Program should continue their efforts, using student input from course evaluations and emphasizing the aspects of the courses that students have liked. As

soon as word gets around that these courses have been overhauled, student enrollment would likely increase, as has already happened when improvements were made. This shift indicates that efforts to address students' academic needs and desires well are crucial to the continued success of the Environmental Studies Program.

REFERENCES

Princeton Environmental Institute Environmental Studies Program: Pat Denton, Janet Gruschow

PERC Audit Academic Opportunities Section: Marlene Haas '97, Amy Marr '96, Farhana Sulatana '96, Mike Sze '97

CONCLUSION

The purpose of conducting a followup to the 1995 PERC audit of Princeton University is to investigate the changes that have taken place over the past five years, and to examine the causes and effects of these changes. By looking at the extent to which the 1995 recommendations have been carried out, and the impacts they have had, we have been able to draw up a new set of broad recommendations better suited to the University campus in the year 2000. Category-specific suggestions have been included under the appropriate chapter. The implementation of the overall suggestions would help bring Princeton to a level of environmental awareness and responsibility that rivals other ecological leaders among universities. Our recommendations have been based on a variety of sources including the policies of other universities,[1] interviews with campus administrators and employees, and reference to the 1995 Audit.

For greatest possible impact of this audit, and the ease of future audits, it is important that the studies be conducted on a more regular basis and include an ever-increasing range of information. While this document is far from comprehensive, we have attempted to expand the scope of the 1995 report. The feasibility and breadth of future audits would be enhanced if University departments were encouraged to keep complete and concise records of the environmental costs, benefits, and considerations of transactions, decisions, policies, and changes. Increasing the accessibility of records would allow quicker and more accurate examination of practices and policies.

As followup to the 1995 PERC audit and examination of the changes in policy made since that time, this 2000 Environmental Audit of Princeton University shows that current ecological improvements on campus are being implemented based primarily on their economic benefits. Fortunately due to the environmental responsibility of the campus, financial savings often result in reductions in environmental impact. The areas of Energy Use, Water Use, Food Services, and both Solid and Toxic Waste were particularly notable in the correspondence between economic and ecological improvements. Increasing the awareness of the complementary relation of these two concerns across all sectors of the University will allow environmental considerations to take a greater role in decision-making processes. When the University realizes that the two fields do not work at cross-purposes and makes a concerted effort to consider both ecological and economic effects during the decision-making process, it will begin to reduce both of these impacts.

[1]Brown University (www.brown.edu/Departments/Brown_Is_Green/), Dartmouth University (www.dartmouth.edu/~esd/winter/winter.html), George Washington University (www.gwu.edu/~greenu/).

The 1995 PERC audit suggested that Princeton create the position of Environmental Coordinator, as has been successfully done at several other universities. After discussing the possibility of such a position with Richard Spies, the vice president of Finance and Administration, and with Mike McKay, director of Facilities, we have concluded that it may not be the best thing for our University. It is unlikely that a single individual could have sufficient knowledge of all areas of the University to make the most efficient and beneficial suggestions. Being removed from the actual departments would create difficulties in working closely with the day-to-day transactions and activities that keep the University running. We also learned that most departments already have one or more people whose job includes considering and evaluating ecological impacts. However, there is little interdepartmental collaboration between these people, making it difficult to come up with creative or innovative ways of improving Princeton's overall environmental practices and policies.

To supply a forum for this type of interaction, we suggest creating a University Environmental Committee, similar to the one recommended by the PERC audit, to guide and direct environmental change on the campus. Members might include one representative from each of the departments consulted during this audit (Building Services, Facilities, Engineering, Planning, Purchasing, Business, Dining Services, etc.), administrative representatives, faculty (including representatives from the Princeton Environmental Institute), and students (including members of campus environmental groups such as Princeton Environmental Action and the Princeton Conservation Society). At regular meetings the committee could go over recent changes in any sector of the University and discuss means for implementing environmentally beneficial change. Such a committee would have a broader reach than an environmental coordinator.

One recommendation is constant in all chapters of this audit: the need to increase awareness. The practices of students, employees, and University departments would improve dramatically if they had a broader understanding of the links between actions and environmental impacts. Several changes can increase this awareness. The formation of a University Environmental Committee would supply departments and administrative sectors of the campus with the information necessary to approach decisions from an ecologically informed standpoint. Educating employees could be done on a departmental scale, with the representative to the Committee taking responsibility for increasing awareness within his or her department.

An understanding of environmental issues and responsibilities is imperative to students not just for their roles as part of the Princeton community, but for their futures as leading citizens of our country and the world. Creating a new distribution requirement that introduced environmental awareness into the mandatory undergraduate course work would guarantee that students graduate from the University as informed and responsible citizens. The environmental distribution requirement could stand on its own and include a wide selection of courses from different areas of both the humanities and the sciences. It could also potentially be integrated into one of the existing distribution requirements of "Social Awareness" or "Ethical Thought and Moral Values," if one or more of the courses taken under either of these topics provide environmental content.

This 2000 audit demonstrates the University's potential to continue reducing its en-

vironmental impact while adding the role of ecological leader to its academic and athletic reputation. Changes must be made as we assume our full environmental responsibilities. We hope that the information provided in this audit will provide a helpful step down the road toward awareness and accountability.